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Parasites and Parasitic Diseases of Domestic Animals in the Hawaiian Islands[1]

JOSEPH E. ALICATA[2]

PARASITES OF ANIMALS have gained entrance to the Hawaiian Islands for a century or more largely with the importation of infected animals from various parts of the world. Because of the mild climatic environment and other favorable factors, these parasites have become established and now constitute an agricultural problem of considerable economic importance. To what extent the people of these islands will be successful in keeping other animal parasites and vectors from entering, especially with the expansion of air and sea transportation, remains to be determined. Much is being done, however, through quarantine, inspection, and other Territorial and Federal regulatory measures to prevent the introduction of additional disease-producing organisms and vectors of disease.

The parasites now present in domestic animals in the Hawaiian Islands are to a large extent the same as are found in continental United States. This is true because most of the animals found in the Islands have come from that area. There are a few parasitic forms, however, which have undoubtedly been introduced from the Orient. These include, at least, *Fasciola gigantica* Cobbold, the common liver fluke of cattle, and *Hymenolepis exigua* Yoshida, a tapeworm frequently found in chickens. In spite of the many parasitic diseases which have been introduced from continental United States, some of the important ones affecting the blood, such as anaplasmosis and piroplasmosis of cattle and dourine of horses, either have not been introduced or have failed to become established.

The present paper represents a résumé of internal and external parasites, and of their intermediate hosts, if any, which have been reported up to the present time from domestic animals in the Hawaiian Islands. Special reference is given to certain species which are of economic importance. Whereas considerable data are available on parasites of chickens, cattle, horses, and swine, information on those of other animals is up to the present time inadequate or entirely lacking. The chief sources of information on the external parasites reported in this paper have been the scattered reports published by various entomologists in the Islands. Data dealing with internal parasites (protozoa, roundworms, tapeworms, and flukes) and any of their intermediate hosts have been secured largely, except as indicated, from the various reports and observations made by the writer during the past several years.

PARASITES OF POULTRY

PROTOZOA

Coccidial organisms, *Eimeria tenella* Railliet and Lucet, are the most important protozoa affecting chickens. Infection with these parasites is as troublesome in Hawaii as it is anywhere else.

Pigeons in Hawaii are commonly infected

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with the malarial organism *Haemoproteus columbae* Celli and Sanfelice (Alicata, 1939*c*). This protozoan lives in the red blood cells and may be responsible for the production of anemia and low vitality. It is spread among pigeons through the bite of the pigeon fly, *Pseudolynchia canariensis* (Macquart), which is generally distributed (Bryan, 1934). *Histomonas meleagridis* (Smith), the causative organism of "blackhead" in turkeys, is responsible for sporadic outbreaks of this disease in various parts of the Islands.

ROUNDWORMS

Up to a few years ago gizzard-worms, *Cheilospirura hamulosa* (Diesing), were widespread among chickens and turkeys in the Territory and were responsible for anemia, emaciation, and deaths, especially among chickens. The infection was checked after the discovery and control of the following arthropods, which were found serving as intermediate hosts (Alicata, 1936; 1938*b*; 1939*c*): (COLEOPTERA) *Carpophilus dimidiatus* Fabricius, *Dactylosternum abdominale* (Fabricius), *Dermestes vulpinus* Fabricius, *Epitragus diremptus* Karsch, *Euxestus* sp., *Gonocephalus seriatum* (Boisd.), *Litargus balteatus* Lec., *Oxydema fusiforme* Woll., *Palorus ratzeburgi* (Wissm.), *Sitophilus oryzae* (Linn.), *Tenebroides nana* Melsh., *Tribolium castaneum* (Herbst), and *Typhaea stercorea* Linn.; (ORTHOPTERA) *Atractomorpha ambigua* Bolivar, *Conocephalus saltator* (Sauss.), and *Oxya chinensis* (Thun.); (AMPHIPODA) *Orchestia platensis* Kröyer.

The eyeworm, *Oxyspirura mansoni* (Cobbold), which utilizes the burrowing roach, *Pycnoscelus surinamensis* (Linn.), is common in chickens in the Islands (Alicata, 1936). This eyeworm has also been found in the English sparrow (*Passer domesticus* [Linn.]) (Illingworth, 1931), the mynah bird (*Acridotheris tristis* [Linn.]), and the Chinese dove (*Streptopelia chinensis* [Scopoli]). On this account, these wild birds are believed to assist in spreading the infection in nature. The parasites are located in the inner corner of the eyeball and in the nictating membrane. In heavy infestations there is a puffiness around the eye, and inflammation frequently results in blindness. Infested birds often wink their eyes continually, and the irritation causes the bird to scratch the eye with the claws for relief. The process of scratching frequently causes mechanical injury to the eyeball and development of secondary bacterial infection. Eyeworm infection is most prevalent in dry areas with loose sandy soil in which roaches thrive. As a means of controlling this disease, the writer has advocated the maintenance of giant toads, *Bufo marinus* (Linn.), in poultry yards. These toads are insectivorous and devour roaches readily.

The poultry ascarid, *Ascaridia galli* (Schrank), and two species of cecal worms, *Heterakis gallinae* (Gmelin) and *Subulura brumpti* (Lopez Neyra), are common among chickens. *S. brumpti* is the most prevalent, and unlike *H. gallinae* requires an intermediate host, which may be any one of the following (Alicata, 1939*a*; Cuckler and Alicata, 1944): (COLEOPTERA) *Alphitobius diaperinus* (Panz.), *Ammophorus insularis* Boh., *Dermestes vulpinus* Fabricius, *Gonocephalus seriatum* (Boisd.), and *Tribolium castaneum* (Herbst); (ORTHOPTERA) *Conocephalus saltator* (Sauss.), *Oxya chinensis* (Thun.); (DERMAPTERA) *Euborellia annulipes* (Lucas). The intestinal roundworm, *Ornithostrongylus quadriradiatus* (Stevenson), has been found common in pigeons in the Islands and is believed responsible for unthriftiness and losses among pigeons (Alicata, 1939*c*).

Other roundworms of chickens which require an intermediate host include the crop worm, *Gongylonema ingluvicula* Ransom, and the proventricular worms, *Tetrameres americana* Cram and *Dispharynx spiralis* (Molin). In continental United States *G. ingluvicula* has been found to utilize the beetle

Copris minutus Drury as an intermediate host. In Hawaii, the related beetle *C. incertus* (Say) may be found to serve as a suitable host. *T. americana* is known to utilize any of the following as intermediate hosts in the Islands (Alicata, 1938*c*): (COLEOPTERA) *Dendrophilus* sp. (probably *D. punctatus* Herbst), *Dermestes vulpinus* Fabricius, *Epitragus diremptus* Karsch, and *Gonocephalus seriatum* (Boisd.); (ORTHOPTERA) *Blattella germanica* (Linn.); and *Conocephalus saltator* (Sauss.); (DERMAPTERA) *Euborellia annulipes* (Lucas); (AMPHIPODA) *Orchestia platensis* Kröyer. The sow bug, (ISOPODA) *Porcellio laevis* Latr., serves as intermediate hosts for *D. spiralis* (Alicata, 1938*c*), which often produces deep ulcerations of the proventricular wall.

FLUKES

The cecal fluke, *Postharmostomum gallinum* (Witenberg), commonly infects adult chickens raised on the ground. Extensive cecal hemorrhages have been found associated with infection by this parasite. Recent studies have shown that two common land snails, *Eulota similaris* (Fer.) and *Subulina octona* (Brug.), serve as intermediate hosts (Alicata, 1940).

TAPEWORMS

Tapeworms are of common occurrence in chickens. Those known in Hawaii include the following: *Choanotaenia infundibulum* (Bloch), *Hymenolepis carioca* (Magalhaes), *Hymenolepis exigua* Yoshida, *Raillietina cesticillus* (Molin), and *R. tetragona* (Molin) (Alicata, 1938*c*).

Various arthropods in Hawaii are known to serve as intermediate hosts for the above-mentioned tapeworms, as follows (Alicata, 1938*c*; Hall, 1929): *C. infundibulum:* (COLEOPTERA) *Dermestes vulpinus* Fabricius, *Epitragus diremptus* Karsch, *Gonocephalus seriatum* (Boisd.), and (DIPTERA) *Musca domestica* Linn.; *H. exigua:* (AMPHIPODA) *Orchestia platensis* Kröyer; *R. cesticillus:* (COLEOPTERA) *Dermestes vulpinus* and *Gonocephalus seriatum; R. tetragona:* probably various species of ants, especially those of the genera *Pheidole* and *Tetramorium*. Members of this group of ants (*P. vinelandica* and *T. caespitum*) are known intermediate hosts of *R. tetragona* in continental United States (Jones and Horsefall, 1935).

ARTHROPODS

Various species of lice are known to infest poultry in the Islands. These include the following (Illingworth, 1928*a*): chicken body louse, *Eomenacanthus stramineus* (Nitzsch); chicken head louse, *Lipeurus heterographus* Nitzsch; common hen louse, *Menopon gallinae* (Linn.), also found on turkeys and guinea hens; fluff louse of chickens and turkeys, *Goniocotes hologaster* Nitzsch; large chicken louse, *Goniocotes gigas* Taschenberg; large turkey louse, *Goniodes stylifer* Nitzsch; peafowl and guinea hen louse, *Menopon phaeostomum* (Nitzsch); turkey louse, *Lipeurus gallipavonis* Geoffroy; and the chicken wing louse, *Lipeurus caponis* (Linn.).

Mites found on chickens include the red mite, *Dermanyssus gallinae* (De Geer); the wing mite, *Pterolichus obtusus* Robin; and the body mite, *Megninia cubitalis* (Megnis) (Alicata *et al.*, 1946). Included likewise is the tropical fowl mite, *Lyponyssus bursa* (Berlese); this mite has also been reported common in nests of English sparrows and mynah birds. It is known to invade houses, where it bites human beings and causes skin irritation (Zimmerman, 1944).

Other arthropods of poultry include the sticktight flea, *Echidnophaga gallinacea* (Westwood) (Illingworth, 1916); the pigeon fly, *Pseudolynchia canariensis* (Macquart) (= *Lynchia maura* Bigot), generally widespread among pigeons (Bryan, 1934); and the biting louse of pigeons, *Columbicola columbae* (Linn.) (Zimmerman, 1944).

Parasites of Cattle

PROTOZOA

Four species of coccidia, *Eimeria cylindrica* Wilson, *E. bovis* Zublin, *E. zurnii* Rivolta, and *E. bukidnonensis* Tubangui, have been recovered from the feces of young calves (Cuckler and Alicata, 1943). Although no severe cases of bovine coccidiosis have been recorded in the Islands, reports elsewhere indicate that infection may produce bloody diarrhea and emaciation.

ROUNDWORMS

In a recent survey involving the examination of about 375 cattle raised on various islands and slaughtered in Honolulu, the following percentages of roundworm infections were found (Cuckler and Alicata, 1943): gullet worms, *Gongylonema pulchrum* Molin, 54.3 per cent; stomach worms, *Haemonchus contortus* (Rudolphi), 0.9 per cent; intestinal roundworms, *Bunostomum phlebotomum* (Railliet), 6.7 per cent; *Cooperia punctata* (v. Linstow), 4.0 per cent; *C. pectinata* Ransom, 0.3 per cent; and the skin filarid, *Stephanofilaria stilesi* Chitwood, 89.8 per cent. Eggs of *Trichuris ovis* (Abildgaard) and *Strongyloides* sp. (probably *S. papillosus*) have at times been found in the feces of cattle in Hawaii.

The intestinal roundworm, *Oesophagostomum radiatum* (Rudolphi), and the lungworm, *Dictyocaulus viviparus* (Bloch), have also been noted by the writer. Lungworm infection is believed to be of considerable importance, especially among calves, in some sections of the Islands, and deaths resulting from this parasite have been recorded (Willers, 1945).

Of the above roundworms, *Stephanofilaria stilesi* and *Gongylonema pulchrum* require an intermediate host in their development. The intermediate host for *S. stilesi* is unknown. *G. pulchrum* is known to utilize one of various coprophagous beetles and roaches as intermediate host in continental United States (Alicata, 1935). Of insects reported as hosts, *Aphodius lividus* (Oliv.), *Dermestes vulpinus* Fabricius, and *Blattella germanica* (Linn.) occur in Hawaii.

FLUKES

Two species of flukes have been recorded from cattle in the Islands. One species consists of an unidentified rumen fluke reported by Hall (1936), and the other species is the liver fluke, *Fasciola gigantica* Cobbold.

Liver-fluke infection is the most important parasitic disease of beef and dairy cattle. Infection with this parasite was first reported by Dr. A. Lutz (1892) as being common on four of the larger islands. Although at that time the parasites were reported as *Fasciola hepatica* Linn., more recent study has shown them to be *F. gigantica* (Alicata and Swanson, 1937). The importation of this fluke into Hawaii is not clearly understood, but it is believed to have come from the Orient with the introduction of water buffaloes. It is of interest to note that the limnaeid snail, *Fossaria ollula* (Gould), which serves as the intermediate host, has Japan and China as its geographic range (Alicata, 1938*a*). This snail is widely distributed in Hawaii and is common in streams and swampy lowlands.

The maintenance of fluke infection in Hawaii, as elsewhere, is dependent on various factors of which topography, climatic conditions, and agricultural practices are very important. The Hawaiian Islands represent the summits of a 2,000-mile range of volcanic mountains which vary from coastal to centric or eccentric in position. The mountains descend to the ocean abruptly, in steep walls or by gradual transition over relatively flat land with very little drainage. These poorly drained lowlands and valleys, especially on the windward side, often present rather extensive swamps. Rainfall is most prevalent in winter months, but showers during other seasons of the year are sufficient to maintain swampy conditions. These wet areas and the mild Hawaiian climate encourage snail prop-

agation the year round as well as the development and hatching of fluke and other parasite eggs. Moreover, agricultural practices in the Islands have encouraged rather than hindered the maintenance of fluke infection. With ample supplies of vegetation, cattle have been allowed to graze continuously. Many dairymen have long been in the habit of feeding cut forage from wet or swampy areas to cattle. These practices have been largely responsible for the widespread fluke infection. This disease is gradually being brought under control largely through (1) use of copper sulfate for the control of the snail vector in swamps or streams, (2) use of forage grass cut from dry areas, and (3) treatment of infected animals with hexachloroethane. This synthetic compound, although first used in fluke control in Europe in 1926 (Thienel, 1926), was first utilized on a large scale in the United States by the University of Hawaii Agricultural Experiment Station (Alicata, 1941*a*).

TAPEWORMS

The infective larval stage "bladderworm" of *Taenia saginata* Goeze has occasionally been found present in the musculature of cattle in the Islands, according to a personal communication received from Dr. A. H. Julien, Federal meat inspector. The larvae reach maturity in the intestine of man, following ingestion of improperly cooked beef. Cattle acquire the infection as a result of eating vegetation contaminated with human feces containing eggs of this parasite. It is generally believed that most cases of human infection occur among immigrants from the Orient, especially the Philippines.

ARTHROPODS

Several dipterous larvae are known to be parasitic on cattle. In a recent examination of 303 animals (Cuckler and Alicata, 1943), 26.1 per cent showed evidence of the cattle grub, *Hypoderma lineata* (De Villers), a fly first reported in the Islands in 1906 (Bryan, 1934). This parasite is recognized as very injurious to cattle, causing loss of flesh and decreasing the value of the skin for leather. Some years ago, Mr. O. A. Pickerill of the Hawaii Meat Company in a personal communication reported that during the year 1934, of 15,099 hides examined, 4,252, or 28.16 per cent, were grubby.

In recent years a report was made of attacks or "fly strike" of blowflies on young calves on the island of Kauai (Holdaway, 1943; 1945). Observations indicated that three species of flies were involved, *Chrysomia megacephala* (Fabricius), *C. rufifacies* (Macquart), and *Lucilia sericata* (Meigen).[3] These flies ordinarily breed in carcasses and other animal matter. However, they may deposit eggs in a number of different places on recently born calves. The eggs hatch and the larvae or maggots feed on the surface layer and cause an inflamed, malodorous wound. Infested calves become spiritless and, unless suitably treated, die in a few days.

Auricular myiasis of cattle caused by the larvae of *C. megacephala, C. rufifacies,* and *Fannia* sp. have been reported by Zimmerman (1944). Species of adult flies which are pestiferous on cattle in the Islands include the horn fly, *Siphona irritans* (Linn.) (= *Lyperosia irritans* [Linn.]), and the stable fly, *Stomoxys calcitrans* (Linn.) (Bryan, 1934).

Lice, *Haematopinus eurysternus* (Nitzsch) (Cuckler and Alicata, 1943) and *Bovicola bovis* (Linn.) (Zimmerman, 1944), have occasionally been found on cattle. General emaciation or unthriftiness is usually associated with infestation.

The spinose ear tick, *Otobius megnini* (Dugès), which was first noted in recent years (Alicata, 1941*b;* Cuckler and Alicata, 1943; Zimmerman, 1944), is widespread on beef cattle. Of 357 cattle examined from

[3] According to a personal communication from F. G. Holdaway, the identification of *Lucilia* is tentative.

Hawaii, Oahu, and Maui, 160, or 44.8 per cent, showed infestation (Cuckler and Alicata, 1943). In several instances the ticks were found in large numbers filling the entire ear canal. These ectoparasites are known to puncture the tender skin of the ear and suck blood. The wounds thus caused often ulcerate and a condition known as ear canker results.

Parasites of Swine

PROTOZOA

There are two types of protozoa infecting swine in the Islands. They are frequently the cause of dysentery, especially among young animals. Included are the coccidia, *Eimeria debliecki* Douwes, *E. scabra* Henry, and *E. spinosa* Henry, and the ciliate, *Balantidium coli* (Malmsten). Various forms of unidentified amoebae and flagellates of unknown pathogenicity are also frequently noted in the feces of swine.

ROUNDWORMS

In 1938 an examination of the feces of 103 grown pigs from the islands of Oahu and Kauai (Alicata, 1939*b*) revealed the following incidence of parasite eggs: *Ascaris suum* Goeze, 21 per cent; *Oesophagostomum dentatum* (Rudolphi), 32 per cent; *Strongyloides* sp., 43 per cent; *Trichuris suum* (Schrank), 7 per cent.

Adult roundworms which have been recovered at necropsy from swine include the following (Alicata, 1938*d*): stomach worms, *Ascarops strongylina* (Rudolphi) and *Hyostrongylus rubidus* (Hassall and Stiles); kidney worms, *Stephanurus dentatus* Diesing; lungworms, *Choerostrongylus pudendotectus* Vostokov and *Metastrongylus elongatus* (Dujardin). Larvae of *Trichinella spiralis* (Owen) have also been found encysted in the musculature of a domestic pig.

Kidney worms and lungworms are most frequently found among hogs raised in open hog lots. According to a personal communication received from Dr. R. N. Beddow, Veterinarian, Territorial Board of Health, of 25,234 hogs slaughtered in Honolulu during 1945 and 1946, 2.8 per cent showed adult kidney worms in the kidney fat. This undoubtedly represents a partial incidence of infection in swine, since no observation was apparently made on the presence of young migrating worms, which are frequently found in the liver and other parts of the body.

Of the above roundworms, lungworms are known to require earthworms as an intermediate host. At least two species of unidentified earthworms recovered from hog lots around Honolulu have been found by the writer to harbor infective lungworm larvae. It is reported that in Hawaii there are about a dozen species of earthworms of the genus *Pheretima* (Williams, 1931). The stomach worm, *A. strongylina*, utilizes one of various coprophagous beetles as intermediate host in continental United States (Alicata, 1935); in Hawaii, beetles of the genus *Aphodius* possibly serve in this capacity.

Because of the occurrence of the first laboratory-proved case of human trichinosis in Hawaii in 1936 (Alicata, 1938*e*), the writer, under the auspices of the Territorial Board of Health, conducted a survey to determine the source and prevalence of trichina infection in nature. This survey revealed the following information: of 61 domestic and 41 wild hogs examined from the island of Hawaii, 1 and 6, respectively, were found infected; of 2,130 rats and 70 mongooses examined, 57 and 17, respectively, showed infection. No trichinae were found in 92, 130, and 30 domestic hogs examined from the islands of Maui, Oahu, and Kauai, respectively. Of 1,904 rats and 22 mongooses examined on Maui, 1 and 2, respectively, were found infected. Of 352 and 601 rats examined from Oahu and Kauai, respectively, none showed infection.

It is of interest to point out that from

1936 to 1945, 58 cases of human trichinosis have been reported in the Islands by the Territorial Board of Health. Most of the infected persons had eaten, or were suspected of having eaten, improperly cooked wild pork or products made from wild pork (Alicata, 1938*e*). According to records of the Territorial Board of Agriculture and Forestry, during the 8-year period from 1933 through 1940 inclusive (Tinker, 1941), 32,724 wild hogs, or an average of 4,090 a year, were killed on five of the larger islands. Because of the moderately high incidence of trichinosis in wild hogs, meat from these animals is believed to constitute a health menace unless proper precautions in cooking, preserving, and refrigerating are taken. Mention may also be made that of 133 human diaphragms examined at random at autopsy in Honolulu, 7.4 per cent harbored trichinae larvae (Alicata, 1942).

FLUKES

No flukes are known to be present in domestic hogs in Hawaii. However, the liver fluke of cattle, presumably *Fasciola gigantica,* has been reported from wild pigs (Shipley, 1913). Wild hogs are descended from domestic forms which have escaped and now roam wild in the mountains, swamps, and waste lands of the Islands.

TAPEWORMS

No adult tapeworms are found in swine, but the infective larval stage "bladder worm" of *Taenia hydatigena* Pallas has been found attached to the liver and omentum of swine (Alicata, 1938*d*). These larvae are known to reach maturity in the intestinal tract of dogs.

ARTHROPODS

The hog mange mite, *Sarcoptes scabiei suis* Linn., is prevalent on swine in the Islands. The louse, *Haematopinus adventicius* (Neum.) (= *H. suis* [Linn.]), is also present (Illingworth, 1928*b*). Infestation with these ectoparasites is very often associated with malnutrition and unhygienic surroundings.

PARASITES OF HORSES

PROTOZOA

No reports are available on protozoan parasites of horses in the Islands.

ROUNDWORMS

According to a recent survey (Foster and Alicata, 1939), horses in Hawaii harbor at least 25 species of roundworms, as follows: *Strongylus equinus* Mueller, *S. edentatus* (Looss), *S. vulgaris* (Looss), *Triodontophorus serratus* (Looss), *T. brevicauda* (Boulenger), *Gyalocephalus capitatus* Looss, *Poteriostomum imparidentatum* Quiel, *Cyathostomum coronatum* (Looss), *Cylicocercus catinatus* (Looss), *C. goldi* (Boulenger), *C. pateratus* (Yorke and Macfie), *Cylicostephanus calicatus* (Looss), *C. longibursatus* (Yorke and Macfie), *C. minutus* (Yorke and Macfie), *C. asymetricus* (G. Theiler), *Cylicocyclus nassatus* (Looss), *C. leptostomus* (Kotlan), *Cylicodontophorus bicoronatus* (Looss), *C. euproctus* (Boulenger), *Trichostrongylus axei* (Cobbold), *Parascaris equorum* (Goeze), *Oxyuris equi* (Schrank), *Probstmayria vivipara* (Probstmayr), *Habronema muscae* (Carter), and *H. microstoma* (Schneider). Of the above parasites, *S. vulgaris* has been found to be somewhat common, a fact suggesting that verminous arthritis and aneurism, caused by the larval stage of this roundworm, are not infrequent among horses in the Islands.

The roundworms of the genus *Habronema* listed above are known to utilize elsewhere various species of flies as intermediate hosts (Hall, 1929). In Hawaii, the house fly, *Musca domestica* Linn., may transmit *H. muscae* and *H. microstoma,* and the stable fly, *Stomoxys calcitrans* Geoffroy, may transmit *H. microstoma.*

FLUKES

According to a report by Hall (1936), liver flukes collected in 1894 from a horse in Honolulu were sent to the U. S. Bureau of Animal Industry. These flukes were originally diagnosed as *Fasciola hepatica* Linn., but a recent re-examination by Mr. A. McIntosh of that Bureau revealed that they are *F. gigantica* (Cobbold). Moreover, veterinarians on the island of Kauai have verbally reported to the writer the finding of fasciolid flukes in livers of horses. Thus far the writer has not confirmed these observations. In recent years the examination of the livers of five horses pastured in known fluke-infested areas failed to reveal liver fluke infection. In addition, a horse and a mule fed experimentally 650 and 2,300 infective liver fluke cysts, respectively, failed to show evidence of flukes or fluke lesions when autopsied a few months later (Alicata and Swanson, 1938). It appears that equines only rarely become infected with liver flukes.

TAPEWORMS

Two species of tapeworms, *Anoplocephala perfoliata* (Goeze) (Foster and Alicata, 1939) and *A. magna* (Abildgaard) (Swanson, 1939), have been reported from horses in the Islands. The intermediate host for each of these parasites is unknown.

ARTHROPODS

The larvae of the "bot flies," *Gastrophilus intestinalis* (De Geer) and *G. nasalis* (Linn.) (Foster and Alicata, 1939), are commonly found attached to the stomach wall of horses in the Islands. Adult flies, *Stomoxys calcitrans* (Linn.), are also pestiferous on horses.

Parasites of Sheep and Goats

PROTOZOA

No reports are available on the protozoa of sheep and goats in the Islands.

ROUNDWORMS

A recent examination (Cuckler, 1943) of a group of sheep from the island of Kahoolawe revealed the following incidence of roundworms: stomach worms, *Haemonchus contortus* (Rudolphi), in 6 of 15 examined, and *Trichostrongylus instabilis* Railliet in 3 of 10 examined; intestinal worms, *Cooperia punctata* (V. Linstow), in 3 of 10 examined, and *Nematodirus spathiger* (Railliet) in 1 of 10 examined.

FLUKES

Specimens of liver flukes collected from sheep in Honolulu were submitted to the U. S. Bureau of Animal Industry in 1892 (Hall, 1936). These specimens, which were originally identified as *Fasciola hepatica* Linn., are doubtlessly *F. gigantica,* since the former is not known to have occurred in the Islands.

TAPEWORMS

Unidentified larval tapeworms or "bladder worms," probably those of *Taenia hydatigena* Pallas, attached to the liver and peritoneum of sheep have been noted by Dr. A. H. Julien, Federal meat inspector (personal communication). The larvae of *T. hydatigena* are known to reach maturity in the intestinal tract of dogs.

ARTHROPODS

In the examination of 60 sheep from the island of Kahoolawe (Cuckler, 1943), 43 harbored the spinose eartick, *Otobius megnini* (Dugès). Reports also indicate the occurrence on sheep of the "sheep tick," *Melophagus ovinus* (Linn.) (Bryan, 1933; Muir, 1928); the "head maggot," *Oestrus ovis* Linn. (Bryan, 1933); and the "Oriental blowfly," *Chrysomyia megacephala* (Fabricius) (Bryan, 1934). The sucking louse, *Linognathus africanus* Kellog and Paine, and the biting louse, *Bovicola caprae* (Gurlt),

have been reported from goats (Zimmerman, 1944).

PARASITES OF DOGS

PROTOZOA

Canine coccidiosis (species unknown) is known to be present in dogs in Hawaii.

ROUNDWORMS

The roundworms known from dogs in Hawaii include the following: intestinal roundworms, *Toxocara canis* (Werner), *Toxascaris leonina* (V. Linstow), *Ancylostoma caninum* Ercolani, *Trichuris vulpis* (Frohlich), and the heartworm, *Dirofilaria immitis* (Leidy). Heartworms are believed to be common in the Islands. Of the three species of mosquitoes in Hawaii, *Culex quinquefasciatus* Say, *Aedes aegypti* (Linn.), and *A. albopictus* (Skuse), the first two have already been incriminated as intermediate hosts for heartworms (Hall, 1929). In a check list of parasites of dogs and cats, Dikmans (1945) lists the lungworm *Filariodes osleri* (Cobbold) from Hawaii. The life cycle of this parasite is unknown.

TAPEWORMS

Dipylidium caninum (Linn.) is the only tapeworm noted in dogs in Hawaii. This tapeworm is known to utilize fleas and lice as intermediate hosts (Hall, 1929). *Ctenocephalides felis* (Bouché) (Pemberton, 1926) and *Trichodectes latus* Nitzsch (Swezey, 1931), which could serve as hosts, are found on dogs in Hawaii. Infective larvae "bladder worms" of *Taenia hydatigena* Pallas have been found attached to the liver and omentum of swine (and sheep ?) in the Islands; from this finding it may be inferred that the adult stage of this parasite is found in dogs.

ARTHROPODS

Arthropods present on dogs in Hawaii include the following: fleas, *Ctenocephalides felis* (Bouché) (Pemberton, 1926) and *Echidnophaga gallinacea* (Westwood); lice, *Trichodectes latus* Nitzsch (Swezey, 1931); a species of kangaroo lice, *Heterodoxus longitarsus* Piaget, collected from a dog in Honolulu (Pemberton, 1934); ticks, *Rhipicephalus sanguineus* (Latreille) (Van Zwaluwenburg, 1934); and undetermined species of mange mites.

PARASITES OF CATS

PROTOZOA

No reports are available on the protozoan parasites of cats in the Islands.

ROUNDWORMS AND TAPEWORMS

Little information is available on roundworms and tapeworms of cats in the Islands. The following were collected by the writer from a stray cat in Honolulu: (ROUNDWORMS) stomach worms, *Physaloptera praeputialis* Von Linstow; hookworms, *Ancylostoma caninum* Ercolani; lungworms, *Aelurostrongylus abstrusus* (Railliet); (TAPEWORMS) *Taenia taeniaeformis* (Batsch) and *Dipylidium caninum* (Linn.). Immature acanthocephalids, determined by Dr. H. J. Van Cleave as *Arhythmorhynchus* sp., have been collected by the writer from the small intestine of a cat. Dr. Van Cleave believes that the cat is not the natural host. Acanthocephalids of this genus are predominantly parasites of water birds.

Among the above parasites, the life cycle of the stomach worm is unknown. The lungworms are known to require snails or slugs as intermediate hosts (Hobmaier and Hobmaier, 1935). The land snail *Subulina octona* (Brug.) was reported by Van Volkenberg (1937) as serving as intermediate host in Puerto Rico; in Hawaii the writer has found that the land snails *S. octona* and *Eulota similaris* (Fer.) may serve for that purpose. Cats may also acquire lungworms from eating infected mice, the latter acquir-

ing the parasite as a result of eating infected snails. In mice, the larvae of lungworms migrate to the musculature, where they become encysted (Van Volkenberg, 1937). The tapeworm, *T. taeniaeformis,* is known to utilize rats or mice as intermediate hosts; the infective larval forms, "bladder worms," are commonly found in the liver of these rodents in Hawaii. The tapeworm, *D. caninum,* utilizes fleas or lice as an intermediate host (see parasites of dogs).

ARTHROPODS

The cat flea, *Ctenocephalides felis* (Bouché), and the sticktight flea, *Echidnophaga gallinacea* (Westwood), are common on cats in Hawaii; the former is also commonly found under houses frequented by cats. The biting louse, *Felicola subrostrata* (Nitzsch), has been collected from cats (Zimmerman, 1944).

PARASITES OF RABBITS

Very little is known about parasites of rabbits in the Islands. Liver coccidia, *Eimeria stiedae* Lindemann, have been noted by the writer on several occasions. The scab mite, *Psoroptes communis* Fürstenberg (Pemberton, 1946), which is commonly found in the ears, has been reported from rabbits.

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SUMMARY OF HOST LIST OF PARASITES AND INTERMEDIATE HOSTS RECORDED IN HAWAII

NAME OF PARASITE	LOCATION IN HOST	INTERMEDIATE HOST*
CAT *(Felis domestica)*		
Roundworms:		
Aelurostrongylus abstrusus	Lungs	Gastropoda: *Subulina octona,*[2] *Eulota similaris*[2] Rodentia: *Mus musculus*[2]
Ancylostoma caninum	Small intestine	
Physaloptera praeputialis	Stomach	(Unknown)
Arhythmorhynchus sp.	Small intestine	(Unknown)
Tapeworms:		
Dipylidium caninum	Small intestine	Siphonaptera and Anoplura (see parasites of dog)
Taenia taeniaeformis	Small intestine	Rodentia: *Mus musculus,*[2] *Rattus rattus alexandrinus,*[2] *Rattus rattus norvegicus,*[2] *Rattus rattus rattus*[2]
Arthropods:		
Ctenocephalides felis	External	
Echidnophaga gallinacea	Attached to skin	
Felicola substrata	External	
CATTLE *(Bos taurus)*		
Protozoa:		
Eimeria bovis	Small intestine	
Eimeria bukidnonensis	Small intestine	

* Legend: (1) = infection found in nature; (2) = determined experimentally; (3) = reported elsewhere for animals similar to those occurring in Hawaii.

Eimeria cylindrica	Small intestine	
Eimeria zurnii	Small intestine	
Roundworms:		
Bunostomum phlebotomum	Small intestine	
Cooperia pectinata	Small intestine	
Cooperia punctata	Small intestine	
Dictyocaulus viviparus	Lungs	
Gongylonema pulchrum	Esophagus	Coleoptera: *Aphodius lividus*,[3] *Dermestes vulpinus*[3] Orthoptera: *Blattella germanica*[3]
Haemonchus contortus	Fourth stomach or abomasum	
Oesophagostomum radiatum	Cecum and colon	
Stephanofilaria stilesi	Skin	(Unknown)
Strongyloides sp. (*papillosus*?)	Small intestine	
Trichuris ovis	Cecum	
Flukes:		
Fasciola gigantica	Liver	Gastropoda: *Fossaria ollula*[1]
(Rumen fluke)	Rumen	(Unknown)
Tapeworms:		
Taenia saginata (cysticercus)	Muscles	Artiodactyla: *Bos taurus*[1] (cattle are intermediate hosts; man is the final host)
Arthropods:		
Bovicola bovis	External	
Chrysomyia megacephala (larva)	In wounds and external	
Chrysomyia rufifacies (larva)	In wounds and external	
Fannia sp. (larva)	External	
Haematopinus eurysternus	External	
Hypoderma lineatum	Under skin	
Lucilia sericata? (see text) (larvae)	External	
Otobius megnini	Inside ears	

CHICKEN (*Gallus gallus*)

Protozoa:		
Eimeria tenella	Ceca	
Roundworms:		
Ascaridia galli	Small intestine	
Cheilospirura hamulosa	Gizzard	Coleoptera: *Carpophilus dimidiatus*,[3] *Dactylosternum abdominale*,[3] *Dermestes vulpinus*,[3] *Epitragus diremptus*,[1] *Euxestus* sp.,[3] *Gonocephalus seriatum*,[3] *Litargus balteatus*,[3] *Oxydema fusiforme*,[3] *Palorus ratzeburgi*,[3] *Sitophilus oryzae*,[3] *Tenebroides nana*,[1] *Tribolium castaneum*,[3] *Typhaea stercorea*[3] Orthoptera: *Atractomorpha ambigua*,[3] *Conocephalus saltator*,[3] *Oxya chinensis*[3] Amphipoda: *Orchestia platensis*[1]
Dispharynx spiralis	Proventriculus	Isopoda: *Porcellio laevis*[1]
Gongylonema ingluvicola	Crop	(Unknown; probably coprophagous beetles)
Heterakis gallinae	Ceca	
Oxyspirura mansoni	Conjunctival sac	Orthoptera: *Pycnoscelus surinamensis*[1]
Subulura brumpti	Ceca	Coleoptera: *Alphitobius diaperinus*,[1] *Ammophirus insularis*,[1] *Dermestes vulpinus*,[1]

* Legend: ([1]) = infection found in nature; ([2]) = determined experimentally; ([3]) = reported elsewhere for animals similar to those occurring in Hawaii.

		Gonocephalus seriatum,[1] *Tribolium castaneum*[2]
		Orthoptera: *Conocephalus saltator*,[2] *Oxya chinensis*[2]
		Dermaptera: *Euborellia annulipes*[1]
Tetrameres americana	Proventriculus	Coleoptera: *Dendrophilus* sp.,[1] *Dermestes vulpinus*,[1] *Epitragus diremptus*,[1] *Gonocephalus seriatum*[1]
		Orthoptera: *Blattella germanica*,[1] *Conocephalus saltator*[2]
		Dermaptera: *Euborellia annulipes*[1]
		Amphipoda: *Orchestia platensis*[1]
Flukes:		
Postharmostomum gallinum	Ceca	Gastropoda: *Eulota similaris*,[1] *Subulina octona*[1]
Tapeworms:		
Choanotaenia infundibulum	Small intestine	Coleoptera: *Dermestes vulpinus*,[1] *Epitragus diremptus*,[1] *Gonocephalus seriatum*[1]
		Diptera: *Musca domestica*[2]
Hymenolepis exigua	Small intestine	Amphipoda: *Orchestia platensis*[1]
Raillietina cesticillus	Small intestine	Coleoptera: *Dermestes vulpinus*,[1] *Gonocephalus seriatum*[1]
Raillietina tetragona	Small intestine	(Probably ants of the genera *Pheidole* and *Tetramorium*)[3]
Arthropods:		
Dermanyssus gallinae	External	
Echidnophaga gallinacea	External	
Eomenacanthus stramineus	External	
Goniocotes gigas	External	
Goniocotes hologaster	External	
Goniodes stylifer	External	
Lipeurus caponis	External	
Lipeurus heterographus	External	
Lyponyssus bursa	External	
Megninia cubitalis	External	
Menopon gallinae	External	
Pterolichus obtusus	External	

DOG (*Canis familiaris*)

Protozoa:		
(Coccidia of undetermined species)	Intestine	
Roundworms:		
Ancylostoma caninum	Small intestine	
Dirofilaria immitis	Heart and pulmonary artery	Diptera: *Aedes aegypti*,[2] *Culex quinquefasciatus*[2]
Filariodes osleri (see text)	Lungs	(Unknown)
Toxascaris leonina	Small intestine	
Toxocara canis	Small intestine	
Trichuris vulpis	Cecum	
Tapeworms:		
Dipylidium caninum	Small intestine	Siphonaptera: *Ctenocephalides felis*,[2] *Pulex irritans*[2]
		Anoplura: *Trichodectes latus*[2]
Taenia hydatigena?	Small intestine	Artiodactyla (see parasites of swine)
Arthropods:		
Ctenocephalides felis	External	

* Legend: ([1]) = infection found in nature; ([2]) = determined experimentally; ([3]) = reported elsewhere for animals similar to those occurring in Hawaii.

Echidnophaga gallinacea	External	
Heterodoxus longitarsus	External	
Rhipicephalus sanguineus	External	
Trichodectes latus	External	
(Mites of undetermined species)	External	

GOAT *(Capra hircus)*

Arthropods:		
Bovicola caprae	External	
Linognathus africanus	External	

GUINEA FOWL *(Numida meleagris)*

Arthropods:		
Menopon gallinae	External	
Menopon phaeostomum	External	

HORSE *(Equus caballus)*

Roundworms:		
Cyathostomum coronatum	Large intestine	
Cylicocercus catinatus	Large intestine	
Cylicocercus goldi	Large intestine	
Cylicocercus pateratus	Large intestine	
Cylicocyclus leptostomus	Large intestine	
Cylicocyclus nassatus	Large intestine	
Cylicodontophorus bicoronatus	Large intestine	
Cylicodontophorus euproctus	Large intestine	
Cylicostephanus calicatus	Large intestine	
Cylicostephanus longibursatus	Large intestine	
Cylicostephanus minutus	Large intestine	
Cylicosternus asymetricus	Large intestine	
Gyalocephalus capitatus	Large intestine	
Habronema microstoma	Stomach	Diptera: *Musca domestica*,[2] *Stomoxys calcitrans*[3]
Habronema muscae	Stomach	Diptera: *Musca domestica*[3]
Oxyuris equi	Colon	
Parascaris equorum	Small intestine	
Poteriostomum imparidentatum	Large intestine	
Probstmayria vivipara	Colon	
Strongylus edentatus	Large intestine	
Strongylus equinus	Large intestine	
Strongylus vulgaris	Large intestine	
Trichostrongylus axei	Stomach	
Triodontophorus brevicauda	Large intestine	
Triodontophorus serratus	Large intestine	
Flukes:		
Fasciola gigantica	Liver	Gastropoda: *Fossaria ollula*[1]
Tapeworms:		
Anoplocephala magna	Small intestine	(Unknown)
Anoplocephala perfoliata	Cecum	(Unknown)
Arthropods:		
Gastrophilus intestinalis (larvae)	Stomach	
Gastrophilus nasalis (larvae)	Stomach	

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PEAFOWL *(Pavo cristatus)*

Arthropods:		
Menopon phaeostomum	External	

PIGEON *(Columba livia domestica)*

Protozoa:		
Haemoproteus columbae	Blood	Diptera: *Pseudolynchia canariensis*[1]
Roundworms:		
Ornithostrongylus quadriradiatus	Small intestine	
Arthropods:		
Columbicola columbae	External	
Pseudolynchia canariensis	External	

RABBIT *(Oryctolagus cunicularis)*

Protozoa:		
Eimeria stiedae	Liver	
Arthropods:		
Psoroptes communis	External	

SHEEP *(Ovis aries)*

Roundworms:		
Cooperia punctata	Small intestine	
Haemonchus contortus	Fourth stomach	
Nematodirus spathiger	Small intestine	
Flukes:		
Fasciola sp. (*gigantica* ?)	Liver	Gastropoda: *Fossaria ollula*[1]
Tapeworms:		
Taenia hydatigena ? (cysticercus)	Attached to liver, mesentery, and omentum	Artiodactyla (see parasites of swine)
Arthropods:		
Chrysomyia megacephala (larvae)	In wounds and external	
Melophagus ovinus	External	
Oestrus ovis (larvae)	Nasal cavities and sinuses of head	
Otobius megnini	Inside ears	

SWINE *(Sus scrofa domestica)*

Protozoa:		
Balantidium coli	Large intestine	
Eimeria debliecki	Large intestine	
Eimeria scabra	Large intestine	
Eimeria spinosa	Large intestine	
Roundworms:		
Ascaris suum	Small intestine	

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* Legend: (1) = infection found in nature; (2) = determined experimentally; (3) = reported elsewhere for animals similar to those occurring in Hawaii.

Ascarops strongylina	Stomach	(Unknown; probably coprophagous beetles of genus *Aphodius*)
Choerostrongylus pudendotectus	Lungs	Macrodrili (earthworms, probably of the genus *Pheretima*)
Hyostrongylus rubidus	Stomach	
Metastrongylus elongatus	Lungs	Macrodrili (earthworms, probably of the genus *Pheretima*)
Stephanurus dentatus	Adults in kidneys and kidney fat; immature forms in liver and other internal organs	
Strongyloides sp.		
Trichinella spiralis	Adults in small intestine, larvae in muscles	
Trichuris suum	Cecum	
Flukes:		
Fasciola sp. (*gigantica* ?)	Liver	Gastropoda: *Fossaria ollula*[1]
Tapeworms:		
Taenia hydatigena (cysticercus)	Attached to liver, mesentary, and omentum	Artiodactyla: *Sus scrofa domestica*,[1] *Ovis aries*;[1] *Canis familiaris*[3] is the final host
Arthropods:		
Haematopinus adventicius	External	
Sarcoptes scabiei suis	External	

TURKEY (*Meleagris gallopavo*)

Protozoa:		
Histomonas meleagridis	Intestine, liver	
Roundworms:		
Cheilospirura hamulosa	Gizzard	(See parasites of the chicken)
Arthropods:		
Goniocotes hologaster	External	
Goniodes stylifer	External	
Lipeurus gallipavonis	External	
Menopon gallinae	External	

* Legend: ([1]) = infection found in nature; ([2]) = determined experimentally; ([3]) = reported elsewhere for animals similar to those occurring in Hawaii.

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Fault at Waimea, Oahu

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INTRODUCTION

THIS PAPER IS PLANNED to show that a fault cuts the shore line of the island of Oahu at Waimea Bay, 7 miles southwest of the north point of the island. It is thought that this is the first time that a fault of appreciable offset has been unequivocally detected in the island of Oahu.

Stearns (1935: 82, 173, 414) makes little mention of faults in his comprehensive report on the geology of Oahu. He thinks that a certain cliff in the Waianae Range, buried by later lava flows, may have been caused by faulting, although he says that the cliff may well have some other origin. He also describes several minor faults.

In regions underlain by extensive, uniform beds of rock, faulting is often manifested by an offsetting of readily identifiable layers along the surface of fracture. In many places the offsets may be seen on valley sides or in artificial excavations. This type of evidence of faulting is not applicable in Hawaii because the individual lava flows vary so much in texture and in thickness that they are not readily identifiable. Continuous tracing of an individual flow is of little use because most flows are rather narrow, and not extensive.

In the uneroded, younger parts of the Hawaiian Islands, bold cliffs have been made by faulting. The block of rock on one side of the fault has been dropped, so that a bold cliff leads up from the edge of the dropped block to the edge of the stationary or relatively raised block. The infacing cliffs at Kilauea and the cliffs that cut the shore line of the island of Hawaii at South Point and at Kealakekua Bay are almost certainly such fault cliffs.

In the strongly weathered and eroded older parts of the Hawaiian Islands, any fault cliffs that may have existed formerly have become much subdued and are no longer conspicuous features of the landscape. The existence of such faults can be demonstrated only by less direct evidence.

In the present paper the hypothesis is adopted that a fault extends inland from Waimea Bay in a direction a little south of east, and that the block on the north side has been raised relative to the block on the south side. Several consequences of this hypothesis are deduced, and the consequences are found to agree with features actually existing in this part of Oahu.

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OFFSETTING OF THE SHORE LINE

Where a coastal region has a seaward sloping surface, and is cut by a fault at a large angle to the shore line, the block that is relatively raised will have its shore line shifted seaward. This kind of offsetting is diagrammatically illustrated in Figure 1, in which the upper sketch represents a dome-shaped island, such as the Hawaiian volcanoes build. The lower sketch shows a similar dome cut by a fault perpendicular to the shore line. The block on the left is the upthrown side and has its shore line displaced seaward from

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the shore line on the right, or downthrown, side. The accompanying maps of the Waimea, Oahu, region (Fig. 2 and 5) show that the shore line has a general trend from northeast to southwest, but that the part northeast of the bay, if continued southwestward, would lie about two thirds of a mile seaward of the southwestern part of the shore line. A fault at Waimea would result in this sort of offsetting of the shore line.

OFFSETTING OF RESTORED CONTOUR LINES

The volcanic domes sketched in Figure 1 have topographic contour lines drawn on them, and it will be noted that on the faulted

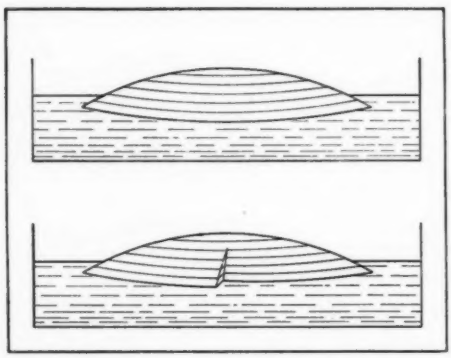

FIG. 1. Diagram to explain offsetting of a shore line by a fault.

dome the lower contour lines are offset like the shore line, but to a lesser distance. The shore line, of course, may be thought of as the contour line of zero altitude. If a fault cut the Waimea Bay region, we should be able to find traces of offsetting of some of the contour lines.

Figure 2 was prepared by tracing as light lines the 500-, 1,000-, 1,500-, and 2,000-foot contour lines from a topographic map of Oahu (U. S. Geol. Survey, 1938) as the first step. The contour lines of the original map were slightly smoothed and generalized in tracing. Next, smoothly sweeping, curved, heavy lines were drawn so as to be tangent

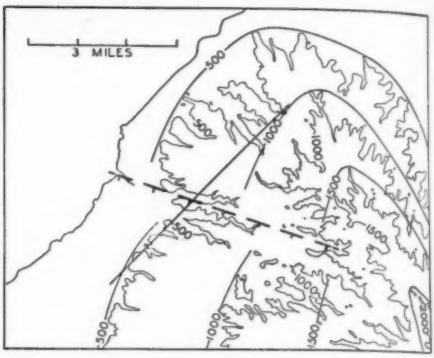

FIG. 2. Generalized contour map of the Waimea, Oahu, region. The light lines are the present-day contour lines; the heavy, smoothly curving lines are restored contour lines; the heavy, broken line shows a reasonable course of the fault, with spurs extending toward the downthrown side; and the straight, heavy line is the line of the profile of Figure 6.

to the seaward salients of the actual contour lines, and thus to form "envelopes" around the present-day contour lines. These smooth, restored contour lines show approximately the shape of this part of the Koolau volcanic dome as it was before dissection by stream erosion had roughened it. The restored contour lines at 500, 1,000, and 1,500 feet have their northeastern parts offset seaward with respect to their southwestern parts in the same way that the shore line is offset, and, presumably, for the same reason.

The precise course of the fault is obscured, but the heavy, broken line of Figure 2 shows a reasonable approximate position. The short lines perpendicular to the several segments indicate the downthrown side of the fault.

HEIGHTS OF WAVE-CUT CLIFFS

Volcanic domes are subject to erosion by streams and by waves. If we neglect the work of streams for the moment, and consider only the work of waves, we realize that the sloping shores would become cliffed, as is suggested in the upper sketch of Figure 3. The sketch cannot show it, but the cliff would

continue below sea level a short distance, and a wave-cut bench would extend seaward from the foot of the cliff. If after the cutting of the cliff the dome-shaped island were faulted, the cliff along the raised part would of course have its crest higher than the cliff crest on the lowered part, as is suggested in the lower sketch of Figure 3. If there were in addition a lowering of sea level or a raising of the whole island, the wave-cut bench might be exposed and would be higher on the upthrown block than on the downthrown block.

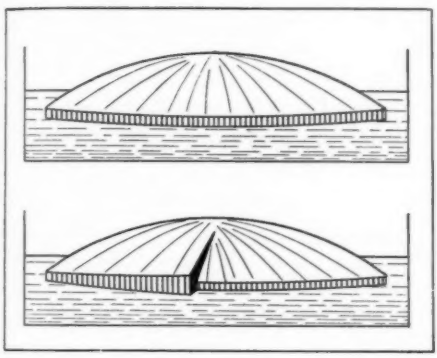

FIG. 3. Diagram to explain how a fault may change the height of sea cliffs.

At some time in the past, waves cut conspicuous cliffs along this part of the shore line of Oahu, just as waves have cut the present striking cliffs along the Hamakua Coast of the island of Hawaii. Later a lowering of sea level exposed the wave-cut bench, on which reefs had been built in the meantime by corals and associated organisms. Streams carrying detritus from inland have built alluvial slopes on the emerged platform. As one drives along Kamehameha Highway, which is on the platform and in general fairly close to the shore, one can see that the wave-cut cliffs are decidedly higher northeast of Waimea Bay than southwest of the bay. This difference in heights of cliffs agrees with the hypothesis of a fault at Waimea Bay.

CONCENTRATION OF PERENNIAL DRAINAGE

Streams on a symmetrical volcanic dome tend to take courses that radiate from the central summit, somewhat like the spokes of a wheel, as is suggested by Figure 4, a

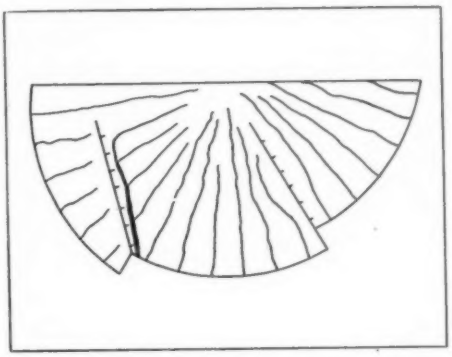

FIG. 4. Diagrammatic map to explain the concentration of drainage by a fault.

diagrammatic map of the stream courses on half of a dome-shaped island. But if the island is faulted, some of the stream courses may be diverted, as is shown at the left in Figure 4. The fault is shown by a straight line with short perpendicular lines on the downthrown side. The fault is seen to divert the headwaters of four streams into one course, which is thereby given an unusually large volume of water and an increased ability to erode. This appears to be what has happened at Waimea Canyon, Kauai, where the stream has cut that remarkably deep canyon. The lowering of the stream bed, partly by downfaulting and partly by its own erosion, has brought it closer to the water table, so that the stream is more generously fed by underground water at all times, and receives some ground water even in the drier seasons.

At the right in Figure 4 another fault is shown, but one about perpendicular to the shore line. Since the course of this fault is radial and essentially parallel to the radial

stream courses, it does not concentrate stream flow to an appreciable extent. The situation at Waimea, Oahu, would seem to be midway between these two types, for our hypothesis supposes a fault only moderately oblique to the shore line.

When Figure 5 was drawn, all the stream

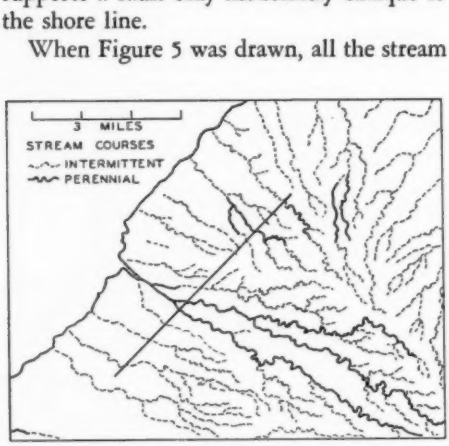

FIG. 5. Drainage map of the Waimea, Oahu, region, showing the concentration of perennial reaches of the streams near the fault.

courses of the region were traced off from the topographic map. Some generalization resulted during the process of tracing. The intermittent reaches of the streams are shown as broken lines and the perennial reaches are shown as heavier, continuous lines. Except in the southeast corner it would be hard to find a point more than a third of a mile away from some stream course, which amounts to saying that the region has been rather intricately cut up into valleys and ridges.

The perennial reaches of the streams, however, show a decided concentration inasmuch as the three that are longest lie rather close to one another and rather close to the position of the suggested fault. The concentration of perennial courses is another item that agrees with the present hypothesis.

PROFILE ACROSS WAIMEA

The heavy, straight lines extending from northeast to southwest in Figures 2 and 5 show the line along which the profile of Figure 6 was constructed. The profile was prepared from the preliminary sheets of the most recent topographic map of Oahu (U. S. Geol. Survey, n.d.), with a horizontal scale of a little over 3 inches to the mile. The vertical scale of Figure 6 is a little over four times as large as the horizontal scale. It will be seen that the high parts of the profile to the left (northeast) of Elehaha Stream are at altitudes around 800 feet, whereas those to the right (southwest) of Kaiwikoele Stream are about 200 feet lower. This difference would result from the vertical offsetting of the two blocks by the suggested fault.

TWO-CYCLE TOPOGRAPHY ON THE UPTHROWN BLOCK

Where the earth's crust is stable, a stream will at first cut a rather narrow and deep valley, but as time goes on the valley becomes wider and more flaring because the rocks of the valley sides weather, become weak, and gradually slump or creep toward the stream. Thus a wider valley, with more gently sloping sides, will be made.

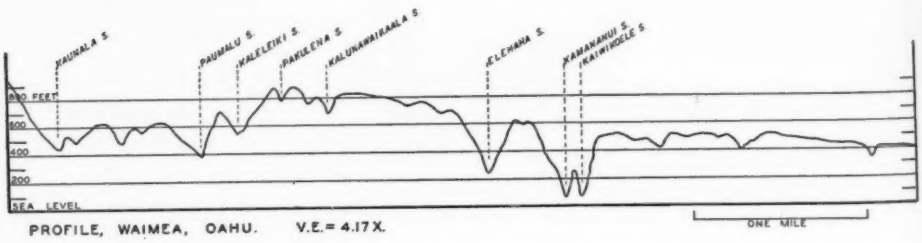

FIG. 6. Topographic profile of the Waimea, Oahu, region, parallel to the shore line.

If the region is later raised, or tilted, so that the stream is given a steeper gradient and a great velocity, the stream will revert to a predominance of deepening over widening, and will cut a new, inner, narrow valley along the trough of the older, outer, broader valley. This process results in what is known as "two-cycle topography," or "valley-in-valley topography," characterized by the break in the transverse profile where the upper and lower valley sides meet. The upper valley was cut during an earlier cycle of erosion and the lower valley during a later cycle.

The hypothesis that there is a fault at Waimea supposes the block on the northeast to have been raised. If this is true, the raising should have rejuvenated the streams and should have produced two-cycle topography. Such topography is found between Pupukea and Kaunala, in an area extending for about 3 miles parallel to the shore line, and lying inland from the crest of the wave-cut cliff. Unfortunately the contour intervals of the maps do not permit constructing a profile that will show the inner and outer valleys. In Figure 7, the inner valley runs from right to left. The photographer stood on a part of the older, upper valley slopes which extend to the middle distance. The pineapple fields on the far side, and the pasture to the right of the pineapple fields, are also on the older, upper valley slopes. The sides of the younger, inner valley are too steep to be tilled, and are partly in brush, partly in grass, and partly bare of vegetation.

THE FAULT SCARP

Where faulting has recently raised one crust block with respect to the adjacent block, a cliff or fault scarp separates the two blocks, and at first is likely to be a conspicuous feature of the landscape. As time goes on, however, the scarp becomes weathered and eroded back, and changes into a more or less subdued and inconspicuous land form. Such is the scarp of the Waimea fault, now that it is rather old. The best place known to the writer from which to view this subdued scarp is the bridge across the small Lauhulu

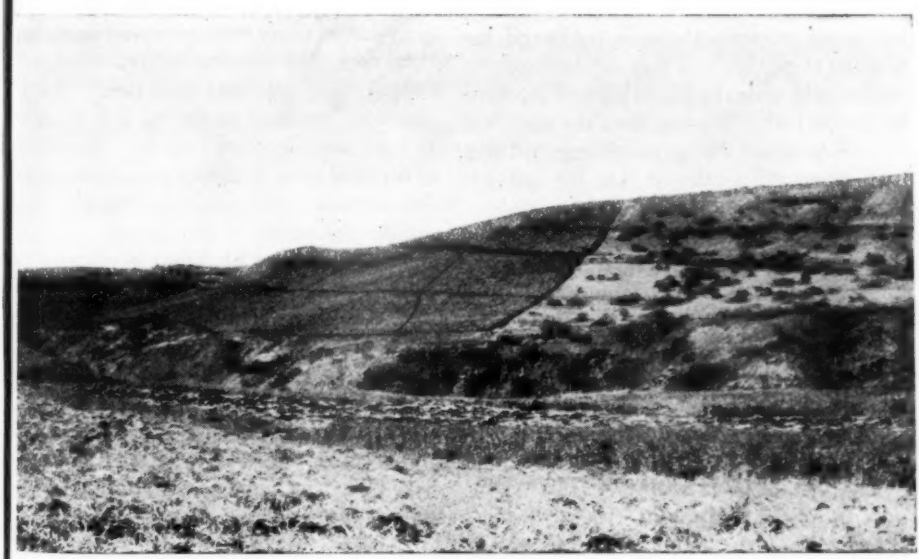

FIG. 7. View of two-cycle or valley-in-valley topography on the upthrown fault block.

Stream, 2.1 miles from Anahulu Bridge at Haleiwa, along Kamehameha Highway, toward Waimea Bay. Figure 8 was photographed from this point. To the right is the old, wave-cut cliff. The cliff leads up to fields of sugar cane, which show up in a rather light shade. The cane fields are on the top of the downthrown block. Beyond the

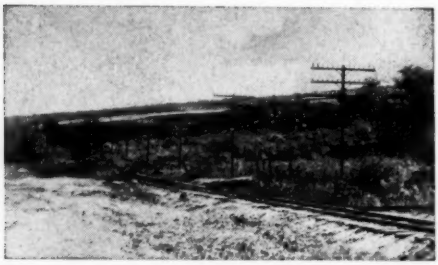

FIG. 8. Distant view of the eroded and subdued scarp of the Waimea, Oahu, fault, from Lauhulu Bridge, looking northeastward.

cane fields (and, in the picture, above the cane fields) is the eroded and subdued scarp of the upthrown block, marked by the darker shade of the trees that grow on it. The picture, of course, cannot show Waimea Valley, but it lies between the cane fields and the wooded slope. Valleys that are due solely to erosion will normally have ridges of the same height on both sides, but since the northeast side of Waimea Valley rises some 200 feet higher than the southwest side, the valley is not solely the product of stream erosion.

DIRECTION OF MOVEMENT

A fault scarp results from the vertical movement of the block of rock on one side of the fault relative to the block on the other side. If one block is actually stationary, the other may move either up or down; or it may be that both blocks move but that one moves farther than the other; or the two blocks may move in opposite directions.

At most of the faults in the Hawaiian Islands the higher block seems to have remained relatively stationary while the lower block moved downward, probably as a result of the removal of support from below. The infacing fault scarps at Kilauea, for example, are thought to have resulted from subsidence of the central block at times when the magma column has receded. The last event of this sort was in May, 1924, when the diameter of Halemaumau, the inner pit, was increased from about one third of a mile to about two thirds of a mile, by the engulfment of the central part, leaving a scarp of sheer cliffs several hundred feet high. A month earlier, subsidence along a fault at Kapoho near the east point of the island of Hawaii made a scarp 8 to 12 feet high, and the sea flooded a part of the block that dropped downward. Numerous other examples of presumed downward movement of fault blocks in Hawaii could be cited.

It is the writer's opinion, however, that at the Waimea, Oahu, fault the lower block remained relatively stationary while the higher block was actually raised, because this assumption appears to be called for by the two-cycle topography on the higher block.

Two-cycle topography results when a region that is fairly well advanced in the erosion cycle has its streams rejuvenated by having their gradients increased. This increase of gradient might be due to either (1) a lowering of sea level or (2) a raising of the land area. If the rejuvenation in question were due to a lowering of sea level, then similar rejuvenation and similar two-cycle topography should be found in many of the older parts of the Hawaiian Islands. In contrast, if the rejuvenation were due to unique uplift of this particular bit of Oahu, other parts of the Hawaiian Islands would not be rejuvenated and would not develop two-cycle topography. Inasmuch as the writer knows of no other places with similar two-cycle topography, he concludes that uplift of the higher, or northeastern, block took place.

The writer freely admits that he cannot show the mechanism by which the northeast-

ern block was raised. A tentative suggestion is that a considerable body of molten matter was intruded under this block, perhaps at the time of the eruptions at Diamond Head and at numerous other young vents in the southeastern part of the Koolau Range.

CONCLUSION

It is not to be expected that one can detect faults in Hawaii by the offsetting of lava flows, because the individual flows are of small lateral extent and because there is great variation in texture and thickness from place to place within each lava flow.

It is believed that faulting occurred at Waimea, Oahu, because this region shows a number of features that would have resulted from faulting, and for which no other explanation comes to mind. These features include:

1. Offsetting of the shore line.
2. Offsetting of the restored contour lines.
3. Higher wave-cut cliffs on the upthrown side.
4. Concentration of perennial stream courses near the fault.
5. A step in the profile across the fault.
6. Two-cycle topography on the upthrown block.
7. A subdued scarp such as prolonged erosion would make of a fault cliff.

The cumulative evidence of these features seems to indicate faulting, although actual offsetting of the rock layers has not been found.

REFERENCES

STEARNS, HAROLD T., and KNUTE N. VAKSVIK. *Geology and ground water resources of the island of Oahu, Hawaii.* 479 p., 34 fig., 33 pl. Ter. of Hawaii, Div. Hydrog., Bul. 1, 1935.

U. S. GEOL. SURVEY. Advance sheets of Haleiwa, Kaipapau and Laie quadrangles of the topographic map of Oahu. Surveyed in 1929 and 1930. Scale 1:20,000; contour intervals 10 and 50 feet. [n.d.]

U. S. GEOL. SURVEY. Topographic map of the island of Oahu, City and County of Honolulu, Hawaii. Scale 1:62,500; contour interval 100 feet, 50-foot contour added. 1938.

Fungi of the Marshall Islands, Central Pacific Ocean

DONALD P. ROGERS[1]

INTRODUCTION

DURING THE LATE SUMMER of 1946 a party from the Department of Botany of the University of Hawaii visited a number of islands of the Marshall group with the purpose of collecting the species which occur there. The party consisted of Dr. Harold St. John, professor and chairman of the department, Mr. Richard S. Cowan, graduate assistant, and the writer. Transportation and living and working quarters were provided by the United States Navy; the journey from Honolulu to Kwajalein, and thence to the more northern islands, was made on a naval vessel, and to the islands south of Kwajalein by seaplane.

Although only 10 of the 34 atolls and single islands making up the archipelago were visited, these lie in both the northern and southern parts of the group, and in both the Radak (eastern) and Ralik (western) chains of which it is composed; and earlier visits by Dr. St. John to other atolls indicate that the 10 visited show nearly all the diversity of climate, topography, and vegetation exhibited by the larger number. It is true that all the islands on which the party landed were inhabited, and it is possible that studies of some of the uninhabited islands would have given a somewhat different impression of the vegetation. This limitation, however, probably is of importance only for the collector of phanerogams; since stands of undisturbed native vegetation occurred on the inhabited islands also, it is unlikely that the others would have proved much more favorable for mycological study.

Fungi were collected on eight atolls and a single island (Mejit); the localities are here listed, in order from north to south, with the dates on which they were visited.

ATOLL (or single island)	ISLAND	DATE (1946)
Utirik	Utirik	September 1–2
Mejit I.	.....	September 3
Ailuk	Nankarai	August 31
	Marab	August 31
	Marme	August 31
	Ailuk	August 30
Likiep	Eniarmij	August 29
	Biebi	August 29
	Likiep	August 28
Wotje	Ormed	September 4–5
	Riri	September 5
Namu	Namu	August 16
	Leuen	August 16
Ailinglapalap	Ailinglapalap	August 20
Jaluit	Imrodj	August 20
Ebon	Ebon	September 9–12

Most of these names are those given on U. S. Hydrographic Office charts 5413 and 5414. The other localities are shown, but not always named, on advance proofs of H. O. charts 6007, 6018, 6020, and 6022. In Ailuk Atoll the ninth island north of Ailuk Island is called by the inhabitants of the atoll "Marab"; that name is used in this report, although the proofs of chart 6022 designate it by the apparently nipponized name "Marappu." The island immediately south of it (and eighth to the north of Ailuk), unnamed on the charts, is called "Marmé" by the Marshallese. The thirteenth island of the series running north from Ailuk has the native name "Nankarai." In Likiep Atoll, Biebi is shown on H. O. chart 6020. The

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island next to Biebi on the northeast, and connected to it by a stretch of reef exposed at low tide, is unnamed on the charts; according to Marshallese informants it is called "Eniarmij." Riri in Wotje Atoll lies next to Ormed on the east; it is named on chart 6018. Imrodj in Jaluit Atoll is shown immediately above "N. E. Pass" on chart 5414, and named on 6007.

August and September fall within the rainy season for the Marshalls, and there had been recent rainfall, enough not only to moisten the soil but even to soak the fallen logs, on all the islands except Ebon; often there were showers or heavy rains during the collecting trips. On Ebon there had been no rain for some time, and the paddies devoted to the cultivation of *Cyrtosperma* contained mud but no standing water; nevertheless, soil and vegetable debris were damp and supported an abundant growth of fungi. On the evidence of the vegetation, as well as of published accounts, there is a considerable increase in rainfall in the archipelago as one goes from north to south; the vegetation of the northern islands is somewhat more open and poorer in species, and lichens and other epiphytes are distinctly less abundant, than in the islands south of Kwajalein. Mejit, in the northern part of the group and also considerably east of its nearest neighbors (Utirik, Ailuk, and Wotje), appears much wetter than they. Ebon, the southernmost atoll of the archipelago, alone of those visited supports the dense tangle of undergrowth and the abundant epiphytes that usually enter into the description of a jungle. Any further attempt to characterize the vegetation is beyond the scope of this report, and must be left for Dr. St. John's account of the vascular plants.

I have been able to discover few discussions of the fungi of the Marshalls. Ehrenberg (1820) described *Scaphophorum Agaricoides, Boletus Katui, B. sanguineus, Sphaeria fur,* and *S. profuga* from collections by Chamisso in the Radak chain; these were reduced to synonymy (*S. Agaricoides* = *Schizophyllum commune, B. Katui* = *Polyporus xanthopus, B. sanguineus* = *P. sanguineus*) or redescribed, and validly published, by Fries (1821: 371, 504, 505; 1823: 431, 488); the two species of *Sphaeria* were transferred to *Metasphaeria* by Saccardo (1883: 182). Hennings (1897) listed or described from Jaluit 13 species, from collections by Schwabe and by Finsch: *Auricularia auricula-judae, Polystictus sanguineus, Schizophyllum Alneum, Fomes amboinensis, Polyporus Kamphoeveneri, Marasmius callopus* var. *jaluitensis* P. Henn., *M. Pandanicola* P. Henn., *Psathyrella disseminata, Psathyra Schwabeana* P. Henn., *Hypholoma jaluitensis* P. Henn., *Galera* sp. (*confertae* aff.), *Pleurotus Schwabeanus* P. Henn., and *Lachnea jaluitensis* P. Henn. Schumann and Lauterbach (1901: 37–63) combined Ehrenberg's and Hennings's lists, treating *Psathyra Schwabeana* under *Pratella* and *Pleurotus Schwabeanus* under *Agaricus,* and, for some incomprehensible reason, reporting *Metasphaeria fur* as *"Metasphaeria Jus."* Volkens (1903: 84) listed only species already reported. No other reports have come to my attention. Thus, unless there are studies published during the Japanese occupation which have been overlooked, the recorded mycobiota of the Marshall Islands embraces 16 species. The University of Hawaii party brought back approximately 425 specimens of fungi, of which 126 specimens, representing 34 species (2 of them new), are here listed. The study of this material is continuing, and other reports will be published.

In the interests of brevity, in listing specimens only the atoll is given where but one island of the cluster furnished collections of fungi, and the date is omitted unless collections were made on an island on more than one day. Except where otherwise noted, the collector is D. P. Rogers and the numbers are *"D. P. R. . . ."* Portions of all Marshallese specimens have been deposited in the Bishop Museum (occasionally indicated by the sym-

bol BISH); portions of all collections of Myxomycetes except three (duplicated by other specimens from the Marshalls), and of all species of Heterobasidiomycetes, are in the herbarium of the University of Iowa (SUI); certain specimens cited are in the Farlow Herbarium (FH); portions of nearly all collections are in the writer's herbarium. Where material is sufficiently abundant, wider distribution has been or will be made. The synonymy given is not intended to be complete; for most species only a few of the more satisfactory and more readily available descriptions are cited.

I am indebted to the University of Hawaii, which through Dean Paul S. Bachman and its Pacific Islands Research Committee assumed the financial burden of the expedition; to Captain John C. Hammock, Commodore Benjamin F. Wyatt, Lieutenant H. B. Wessinger, and those other officers of the United States Navy who facilitated our journey to the Marshalls; to Professor G. W. Martin of the University of Iowa, who named a number of the Myxomycetes and made available extensive manuscript notes on *Auricularia;* to Professor J. N. Couch of the University of North Carolina, for notes on material of *Septobasidium;* to Miss Hilda Harris of the Farlow Library, who verified citations of works not available in Hawaii; and to Dr. St. John and Mr. Cowan, whose assistance and companionship made the journey an agreeable as well as a productive one.

Myxomycetes

1. Arcyria denudata (L.) Wettst.—Utirik, *1657;* Mejit, *1492, 1642, 1660;* Likiep: Likiep I., *1651;* Jaluit, *1649;* Ebon, *1631.*

2. Arcyria nutans (Bull.) Grev.—Likiep: Biebi I., *1652.*

3. Ceratiomyxa fruticulosa (Muell.) Macbr.—Mejit, *1628;* Wotje: Ormed I., *1661,* Riri I., *1629;* Ebon, *1634.*

4. Comatricha Typhoides[2] (Bull.) Rost.—Mejit, *1643;* Jaluit, *1647;* Ebon, *1636.*

5. Cribraria tenella Schrad.—Jaluit, *1650, 1662.*

6. Dictydium cancellatum (Batsch) Macbr.—Ailuk: Ailuk I., *1653.*

7. Fuligo septica (L.) Wiggers—Ebon, *1627, 1638.*

8. Hemitrichia serpula (Scop.) Rost.—Namu: Leuen I., *1648;* Ebon, *1635.*

9. Hemitrichia stipitata (Mass.) Macbr.—Ailuk: Ailuk I., *1654, 1706;* Wotje: Ormed I., *1640;* Ebon, *1632.*

10. Hemitrichia vesparium (Batsch) Macbr.—Ailuk: Ailuk I., *1710;* Ebon, *1637.*

11. Perichaena depressa Lib.—Ebon, *1630.*

12. Physarella oblonga (Berk. and Curt.) Morg.—Ailuk: Ailuk I., *1708;* Jaluit, *1646.*

13. Physarum tenerum Rex—Mejit, *1641;* Ailuk: Ailuk I., *1655.*

14. Physarum viride (Bull.) Pers.—Utirik, *1659.*

15. Physarum Wingatense Macbr.—Ailuk: Nankarai I., *1712;* Wotje, Ormed I., *1645,* Riri I., *1626, 1639.*

16. Stemonitis fusca Roth—Utirik, *1658;* Ailuk: Ailuk I., *1656;* Likiep: Likiep I., *1625.*

17. Stemonitis splendens Rost.—Likiep: Biebi I., *1644.*

None of the Myxomycetes collected is sufficiently uncommon or unusual to be

[2] As in all other matters, I have attempted to follow the existing provisions of the International Rules with respect to orthography. Cf. Rec. XLIII, and the addition voted at Amsterdam.

worthy of comment. The circumscription and nomenclature are those of Macbride and Martin (1934).

PHYCOMYCETES

18. GLAZIELLA AURANTIACA (Berk. and Curt.) Cooke, Grevillea 11: 83, 1883; Lloyd, Mycol. Writings 7: 1203–1204, pl. 248, fig. 2484, 1923; Boedijn, Buitenzorg Jard. Bot. Jour. 3 ser. 11: 57–66, fig. 1–7, 1930. *Xylaria aurantiaca* Berk. and Curt., Linn. Soc. [London] Jour. Bot. 10: 382, 1868. *Glaziella vesiculosa* Berk., Naturhist. For. Kjobenhavn Vidensk. Meddel., 1879–80: 31, 1879; Thaxter, Amer. Acad. Arts and Sci. Proc. 72: 334, pl. 4, fig. 88–94, 1922.

Fructifications tuberiform, bladderlike, approximately isodiametric or flattened, plicate, scarlet, growing paler toward the base, tough-membranous, hollow, opening by an irregular fissure either at the base or above, about 1.5–5 cm. in greatest diameter, early partly enveloped in a white byssoid veil, later free, the surface slightly roughened; hyphae of the veil 4.5–5 μ in diameter, their walls asperulate, about 0.5 μ thick, the lumen interrupted at intervals of 15–60 μ by thin septa; wall of fructification composed of compact outer layers of hyphae with inflated cells up to 10 μ in diameter; of medullary hyphae loosely interwoven, septate, 2–3 μ in diameter; and of embedded chlamydospores; chlamydospores ellipsoid, about 300 × 200 μ, with a rigid wall 17–19 μ thick and an outer apparently gelatinized membrane 5–7 μ thick, enclosing fluid material with numerous oil globules.

On the surface, or under loose fragments, of well-decayed vegetation, chiefly leaves of *Cocos nucifera.* Ebon, R. S. Cowan and D. P. R. (*D. P. R. 1343*).

The fungus is characterized adequately for recognition merely as having hollow, red, membranous fructifications; the few microscopic details given are only for possible microscopic comparison with other material, for it is less than certain that the Ebon collection is conspecific with those reported from the American tropics. Thaxter writes of the "conspicuous orange yellow color" of *G. aurantiaca;* and the specific epithet seems (except by Boedijn) to have been taken without challenge at its face value. The carrying of a copy of Ridgway to the humid tropics seemed too hazardous, and no color comparison could be made in the field; but the fructifications certainly were not orange. My recollection is that the deepest-colored would come close to Scarlet-Red,[3] or at least Scarlet, and the paler basal portions were not yellowish, but a clear rosy pink. The collectors of Boedijn's specimens gave the color as "dunkel steinrot" and "orangerot." Presumably neither Thaxter nor Berkeley nor Curtis ever saw the fungus in living condition; and in 2 months the Marshalls collection has faded to various orange-yellow shades, and in both color and consistency could very well be taken for slightly defective dried peaches or apricots. Without knowledge of fresh American material it would be rash and useless, therefore, to attempt to distinguish the fungus from *G. aurantiaca* by its color. Boedijn, whose admirable account gives an excellent idea of the Ebon material (except that the living specimens here reported were not in the least gelatinous), found no obstacle to the treatment of his specimens under the early name. Mr. Cowan found the greater number of fructifications (11 were collected) in deep shade under a tangle of bushes in a dense grove of coco palms. The species is reported from half a dozen islands of the West Indies, from Brazil and Mexico, and from two islands in the Netherlands Indies. Lloyd (*loc. cit.*) described a second species from Nicobar Island, which in Thaxter's opinion (Stevenson and Cash, 1936: 3) may be identical. There are other synonyms.

BASIDIOMYCETES

19. TULASNELLA ALLANTOSPORA Wakef. and Pears., Brit. Mycol. Soc. Trans. 8: 220, fig. 7, 1923; Rogers, Ann. Mycol. 31: 190,

[3] Color-names capitalized are used in the sense of Ridgway (1912).

pl. 6, fig. 5, 1933; Martin, Iowa Univ. Studies in Nat. Hist. 18 (3): 18, pl. 1, fig. 4, 1944.

On rotten, friable wood of *Artocarpus incisus*. Ebon, IX.10.46, *1366*.

Like a number of European and American specimens, that from Ebon was a barely perceptible bloom when living, and dried is, except under the binocular, wholly invisible. It can readily be recognized in microscopic preparations by the four inflated epibasidia and the thick-allantoid spores. The latter in the collection cited are mostly 7–7.5 × 3.5–4 μ, relatively stout, like the type, but very little tapered toward the ends, more like some Iowa material. Previously reported from western Europe and from the northeastern quarter of the United States, the southernmost station being in Missouri. Martin (1939: 242) has reported two other species of *Tulasnella* from the tropics: *T. violea,* a common species of western Europe, the northeastern states, and southeastern Canada, from Colombia; and *T. sphaerospora,* unknown elsewhere, from Panama. *Gloeotulasnella calospora* occurs in Hawaii.

20. CERATOBASIDIUM CORNIGERUM (Bourd.) Rogers, Iowa Univ. Studies in Nat. Hist. 17: 5, pl. 1, fig. 2, 1935; Martin, *ibid.* 18 (3): 14, pl. 1, fig. 1, 1944.

On decorticate wood of *Artocarpus incisus*. Likiep: Likiep I., *1501*.

A grayish-pruinose growth showing under the microscope repent mycelium; obovate, aseptate hypobasidia bearing (usually) four tubular epibasidia like those of a tremella; and oblong-ellipsoid spores. The shape of the spores reaches the extreme of elongation known in this species, quite like Figure 2(g) of the Iowa paper. Hitherto reported from the Austrian Tyrol and central France in Europe, and in the Western Hemisphere from southern Canada and the northern states. In comparing the Likiep specimen with mainland material, I observed, in *D. P. R. 144* from Iowa, basidia with five well-developed epibasidia. More than four epibasidia or spores apparently are developed elsewhere in the Tremellales only in *Gloeotulasnella*.

21. SEBACINA CINEREA Bres., Fung. Trid. 2: 99, pl. 210, fig. 2, 1892; Rogers, Iowa Univ. Studies in Nat. Hist. 15 (3): 12, pl. 1, fig. 4–6, 1933; McGuire, Lloydia 4: 37, pl. 5, fig. 91–94, 1944; Martin, Iowa Univ. Studies in Nat. Hist. 18 (3): 39, 1944. *Exidiopsis cerina* Möll., Protobas. 85, 167, 1895. *Thelephora cinerea* (Bres.) Sacc. and Syd., Syll. Fung. 16: 183, 1902; nec Pers. ex Fr., Syst. Mycol. 1: 453, 1821.

On rotten, friable wood of *Artocarpus incisus*. Jaluit, *1580*.

A thin cinereous-buff crust, under the microscope showing irregularly linear gloeocystidia with often yellow-granulose content, ellipsoid cruciate-septate basidia, and obtuse cylindric spores. The fructification cited is young, and thinner than is usual for the species. Its spores, which have the form characteristic of *S. cinerea,* are smaller than in most collections (7.5–8.5 (–10) × 4–4.5 (–5) μ), and near the lower limit of size published for the species. The form of the basidia and the degree of compactness of the hymenium, both significant characters in the subgenus *Bourdotia* to which the species belongs, are typical.

The two synonyms given are an addition to those cited in previous discussions. The comparison of Möller's descriptions with good material of *S. cinerea* leaves little need for hesitation in equating his *Exidiopsis* to the present species. Acceptance of that synonymy extends the range of *S. cinerea* to southern Brazil; its known range already stretches from Ontario to Panama, from Massachusetts to Oregon, and in Europe from Finland to Italy.

22. SEBACINA DUBIA (Bourd. and Galz.) Bourd.; Rogers, Iowa Univ. Studies in Nat. Hist. 15 (3): 11, pl. 1, fig. 1–3, 1933;

McGuire, Lloydia 4: 31, pl. 4, fig. 73–74, 1941; Martin, Iowa Univ. Studies in Nat. Hist. 18 (3): 37, 1944. *Heterochaetella dubia* (Bourd. and Galz.) Bourd. and Galz., Hym. Fr. 51, fig. 30 [1928].

On dead wood of *Cocos nucifera.* Ebon, IX.9.46, *1391.*

The fructification is distinctly cretaceous and, unlike that in most specimens of the species, clearly visible to the naked eye—and about as conspicuous as a thin dab of whitewash. Under the lens it is seen to consist of numerous more or less separated whitish conical spicules; under the microscope each of these may be seen to be composed of a number of parallel cystidia, surrounded and conglutinate by a film of indistinct hyphae which ascend for fully two thirds of the height of the spicule and bear on their surface cruciate-septate basidia with four very short epibasidia continued in long, subulate sterigmata. The cystidia of the Ebon specimen differ somewhat from those developed in other collections; but as noted elsewhere, the same may be said of almost any specimen: they are a variable lot. The cystidia, rather than being straight, thick-walled and with a narrow lumen at the base, and thin-walled and with a dilated lumen at the summit, as often in *Peniophora* sect. *Tubuliferae,* are contorted, often several times septate, constricted at some septa or for the entire length of some of the segments, and with the wall only slightly thickened. They show considerable resemblance to those of *Peniophora pallidula.* Some, however, approach the regularity of more typical *Sebacina dubia.* Known from widely separated localities in temperate Europe and North America; reported by Martin (*loc. cit.*) from Brazil.

23. **Sebacina farinacea** sp. nov. Fig. 1.

Fructificatio viva alba, farinaceo-ceracea, margine attenuato, zona peripherica sub lente e granulis albis distinctis (cystidiis) composita, exoleta pallide griseo-pruinosa, sicca cretacea vel leviter sordida; hyphae nodoso-septatae, 1.5–3 μ diam.; paraphyses sparsi, tenues, ramosi; cystidia e corporibus cylindraceis 3–4 μ diam., valde granulis calcareis incrustatis, composita, stipitata, subfusiformia, 20–33 × 7.5–10 μ; gloeocystidia linearia, irregularia, matura suco luteo granuloso suffulta, 17–50 × 5–6 μ; basidia cruciato-septata, ellipsoidea vel oblonga, 14–16.5 (–18) × 8.5–11.5 μ, epibasidia quattuor 2–2.5 μ diam., long. ad 16 μ, gerentia; sporae oblongo-ellipsoideae vel obovatae, 8–9.5 × 6–7 μ, per repetitionem germinantes.

Fructification when fresh pure white, becoming slightly creamy (a little lighter than Cartridge Buff), adnate, separable in small bits, farinaceous-waxy, under the binocular with minutely farinaceous surface, thinning out at the margin to a peripheral zone composed of minute white granules (cystidia) arising out of a thin transparent waxy film; old specimens grayish-pruinose; when dry chalky white to barely cream (paler than Ivory Yellow) or in older fructifications nearly as dark as Cartridge Buff; hyphae distinct, with clamps throughout, 1.5–3 μ; paraphyses scattered, reaching the surface, mostly inconspicuous, the stalk linear, 2–3 μ in diameter, with peg-like or contorted branches 1 μ in diameter; cystidia arising at the margin and later engulfed by the hymenium and lying at its base, composed of a subcylindric, thin-walled cell 3–4 μ in diameter and heavy coarse mineral incrustation, at maturity subfusiform, obtuse, stalked, 20–33 × 7.5–10 μ; gloeocystidia arising near the base of the fructification, somewhat sinuous, irregularly inflated or constricted, thin-walled, the content early hyaline and homogeneous, later yellow, granular, refractive, resinoid, 17–50 × 5–6 μ; basidia subtended by a proliferative clamp, ellipsoid, becoming oblong and truncate, 14–16.5 (–18) × 8.5–11.5 μ, longitudinally cruciate-septate, bearing 4 epibasidia 2–2.5 μ in diameter and up to 16 μ or more in length; spores oblong-ellipsoid to obovate, 8–9.5 × 6–7 μ, germinating by repetition.

On dead fibrous leaf sheaths, leaf bases, and husks of *Cocos nucifera.*

HAWAII: Oahu: University of Hawaii campus, Manoa, II.12.46, I. A. Abbott and D. P. R. (*D. P. R. 655*); II.17.46, *1132;* III.20.46, I. A. Abbott and D. P. R. (*D. P. R. 1175*), and *1176;* III.31.46, *1243;* VI.21.46, *1327, 1328;* X.29.46, *1884,* type (in herb. D. P. R., BISH, SUI); X.30.46, *1888;* XII.4.46, *1931.*

MARSHALL ISLANDS: Ebon, IX.10.46, *1388.*

To the naked eye *Sebacina farinacea* presents the appearance of one of the innumerable small white Thelephoraceae—perhaps

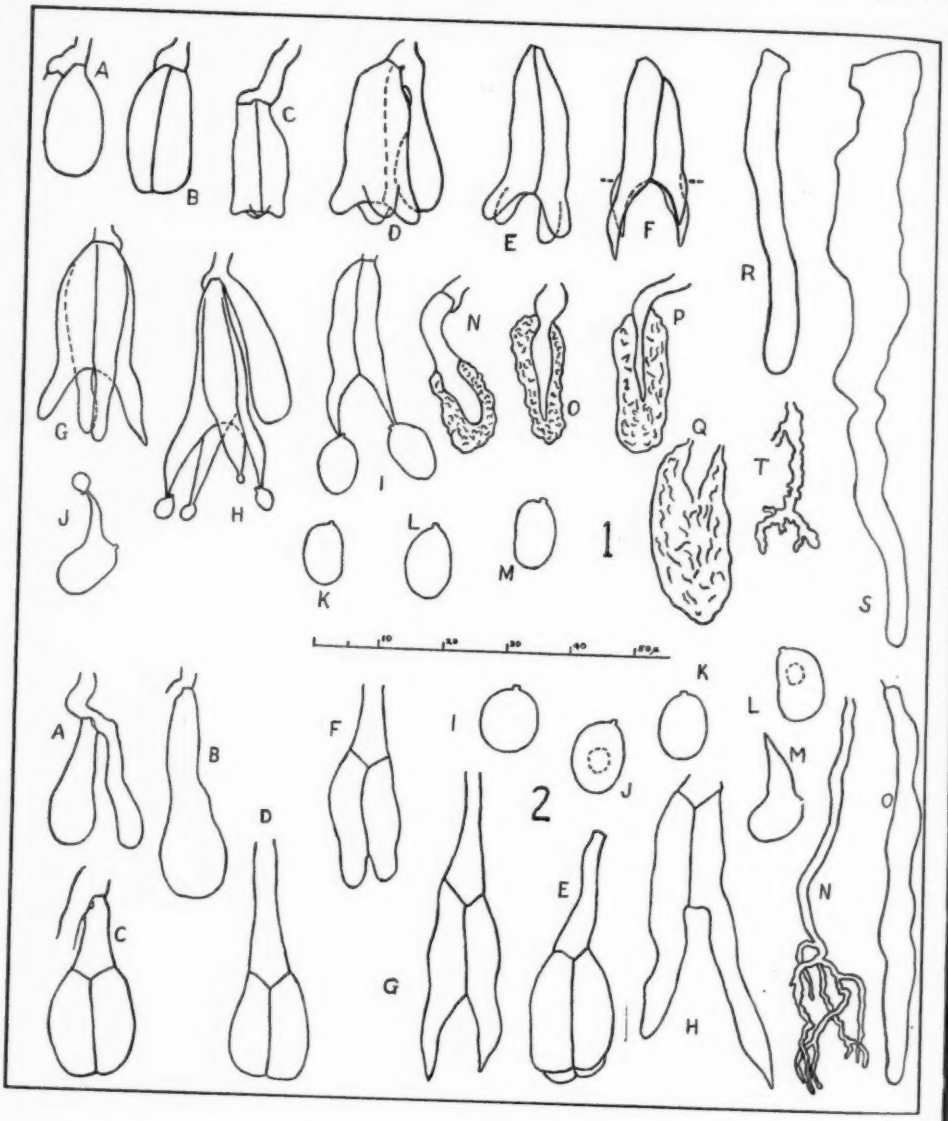

FIG. 1. *Sebacina farinacea:* A–I, basidia; J–M, spores; N–Q, cystidia; R–S, gloeocystidia; T, paraphysis. C, F, I, K, M, N, O, Q, S = *D.P.R. 1888;* A, B, D, E, G, H, J, L, P, R, T = *D.P.R. 1931. 1475.*

FIG. 2. *Sebacina petiolata:* A–H, basidia; I–M, spores; N, paraphysis; O, gloeocystidium. All *D.P.R.*

All drawings were made with camera lucida under oil-immersion objective and 10× ocular at 1675×, and reduced in reproduction to approximately 1000×. Fig. 1 B and I and 2 C, D, and F–H are incomplete (optical section) and do not represent two-celled basidia.

a thin growth of *Corticium suecicum* or *Peniophora Sambuci*. In structure it is most nearly allied to those species of *Sebacina* subgenus *Bourdotia* with well-developed paraphyses, such as *S. Galzinii;* its gloeocystidia are similar, as are the arrangement of the basidia and their frequent elongate form. It is, however, much less gelatinous, and more resistant to separation of the hymenial elements under the cover-glass. On the other hand, its possession of paraphyses and commonly elongate basidia separate it from the group of more arid species of which *S. caesio-cinerea,* for example, is a member, and it does not show the sheath of empty basidia surrounding the fertile hypha that is so characteristic of those species. The heavily encrusted cystidia, resembling those of *Peniophora pubera,* are apparently unique in *Sebacina.* In fact, their place of formation—in a peripheral zone, where they mature before any other hymenial elements are developed —seems to be unique in the whole known range of the Basidiomycetes.

The subgenus *Heterochaetella* is defined by the possession of cystidia. *Sebacina farinacea* shows no indication of affinity to the species of *Heterochaetella* other than its cystidia; and even that exists only because the term "cystidium" is employed for a number of very different structures. The affinities of *S. farinacea* being rather with *S. Galzinii,* it is assigned to the subgenus *Bourdotia.*

Since the available keys to *Sebacina* all make use of the dichotomy "gloeocystidia present : cystidia present" in one form or another (Bourdot and Galzin, 1928: 17; Rogers, 1935: 37; McGuire, 1941: 11; Martin, 1944: 35), *S. farinacea* can be included most readily by the insertion of an additional choice:

"Both gloeocystidia and encrusted cystidia present.....*S. farinacea.*"

Sebacina farinacea can be found after almost any prolonged rainy period on the dead sheaths of leaves attached to young coco palms. Probably it could be collected more abundantly if the bases of the leaves of mature trees were less inaccessible. The Ebon specimen is the only one found elsewhere—on the rotting husk of a coconut. It is quite old and poor, but recognizable.

24. **Sebacina petiolata** sp. nov. Fig. 2.

Fructificatio viva gelatinosa, opalea vel hyalina, luteo-, roseo-, vel cyaneo-tincta, 0.5–3 mm. crassit., sicca hyalino- vel ochraceo-vernicosa; hyphae plerumque distinctae, nodoso-septatae, 2–2.5 μ diam., sub basidiis ad 5 μ expansae; paraphyses filiformes, apicem versus furcatae vel fruticulosae, raro nodoso-septatae, 1–3 μ in diam.; gloeocystidia primo hyalina, homogenea, serius luteo-granulosa, irregulariter subcylindracea vel subfusiformia, obtusa, 39–150 × 4–7 μ; probasidia primo clavata, hypobasidia matura obpyriformio-clavata, cruciatim septata, 21–32 × 9–12.5 μ, ad apicem lobata, epibasidia 4 crassa, 10–50 × 3–5.5 μ gerentia, basidiorum stipitibus ab hypobasidio separatis a septis eisdem verticalibus parietem versus curvatis; sporae hyalinae, ellipsoideo-oblongae vel ellipsoideo-subglobosae, 7–11 × 6–8 μ, per repetitionem germinantes.

Fructification gelatinous, hyaline or yellowish-, pinkish-, bluish-, or plumbeous-opalescent, 0.5–3 mm. thick, the margin attenuate or abrupt and ciliate, when dry hyaline- or ochraceous-vernicose; hyphae mostly distinct, with clamps throughout, 2–2.5 μ in diameter, broadened up to 5 μ just below the basidia; paraphyses filiform, near the tips forked to bushy, occasionally nodose-septate, the basal portion 1.5–3 μ in diameter, the tips contorted, nodulose, unencrusted, about 1 μ in diameter, finally obscure; gloeocystidia with hyaline homogeneous content, becoming coarsely yellow-granular, irregularly subfiliform, subcylindric to fusiform or clavate, obtuse, 39–150 × 4–7 μ; basidia arising as clavate bodies, becoming obpyriform-clavate, the hypobasidia cruciate-septate, lobed at the summit, the inflated terminal portion 16–24 × 9–12.5 μ, the stalk 20–27 × 3–4.5 μ, separated from the fertile summit by the longitudinal walls, which curve away from their line of intersection to meet the outer wall, the epibasidia very thick near their bases, 10–50 × 3–5.5 μ; spores hyaline, evenly oblong to ellipsoid-oblong, 9–11 × 6–7.5 μ, or ellipsoid-subglobose, 7–9 × 6–8 μ, germinating by repetition.

Growing over bark of a dead branch (unidentified), over an old fungus, and on wood of *Acacia Koa, Aleurites moluccana, Artocarpus incisus, Hibiscus Arnottianus, Messerschmidia argentea, Psidium Guayava, Samanea Saman* (=*Pithecolobium Saman*),

Pandanus sp., and bark and wood of *Cocos nucifera.*

CUBA: Blanco's Woods, Soledad, Cienfuegos, VII.1.41, *W. L. White 596;* San Blas, Santa Clara Prov., VI.20–21.41, *W. L. White 407, 427* (all in FH).

HAWAII: Oahu: east slope Manoa Valley (500–900 ft.), XI.18.45, *1218;* Tantalus Trail, Pauoa, VII.21.46, *1331;* S. branch of N. fork of Ekehanui Gulch (1,800–2,400 ft.), Honouliuli, III.17.46, *1169;* Kupehau Gulch above pipe-line trail (2,000 ft.), Honouliuli, X.13.46, *R. S. Cowan 179.*

MARSHALL ISLANDS: Utirik, IX.1.46, *1525, 1548;* Mejit, *1436, 1441, 1450, 1513, 1514, 1545;* Ailuk: Marab I., *1571,* Ailuk I., *1665, 1701;* Likiep: Likiep I., on log of *Cocos,* VIII.28.46, *1475,* type (in herb. D. P. R., BISH, SUI, FH); Wotje: Ormed I., IX.4.46, *1385,* Riri I., *1500;* Namu: Leuen I., *1403, 1431;* Jaluit, *1617;* Ebon, IX.9.46, *1393.*

A continuous, usually thick gelatinous layer, composed (under the microscope) of branched paraphyses, gloeocystidia, and cruciate-septate basidia whose fertile distal part is separated from the stalk-like basal part by the intersecting vertical walls, which turn out to meet the outer wall of the hypobasidium. The apparent color varies considerably, according to the thickness, the color of the substratum which shows through the clear or opalescent basidiocarp, and probably other factors. The collection from Kupehau when fresh was pinkish—Pallid Mouse Gray to Pale Vinaceous-Fawn, whereas the one from Ekehanui, not far away, was in part Pale Olive-Gray and in part colorless and merely pruinose; others were noted in the field as being yellowish-opalescent, bluish-opalescent, blue-white, lavender-gray, light neutral gray, and deep blue-gray. In texture and presence of gloeocystidia and paraphyses *S. petiolata* is related to *S. Galzinii* and *S. umbrina,* from both of which it differs in the manner of branching of the paraphyses, in clavate basidia, and in spores. The presence of the stout stalk separated by the vertical septa from the fertile portion is the clearest recognition-character. The new species may be accommodated in Martin's, McGuire's, or Rogers's keys (earlier cited under *Sebacina farinacea*) by the addition of a third choice to the dichotomy separating *S. umbrina* and *S. Galzinii* (or *S. Pululahuana*):

"Gloeocystidia similar to those of *S. Galzinii* (*Pululahuana*); spores oblong, ellipsoid-oblong, or ellipsoid-subglobose, 7–11 × 6–8 μ; basidia subclavate, the stalk separated by the vertical walls from the fertile summit ..... *S. petiolata*"

25. STYPELLA MINOR Möll., Protobas. 77, 166, pl. 4, fig. 7, 1895; Martin, Iowa Acad. Sci. Proc. 36: 128 [1930]; Iowa Univ. Studies in Nat. Hist. 16 (2): 147, fig. 2, pl. 6, 1934; *ibid.* 18 (3): 34, 1944.

On dead rhachis and charred wood of *Cocos nucifera,* bark and wood of *Pandanus* sp., dead wood of *Artocarpus incisus,* bark and wood of *Carica Papaya,* and decorticate log of unidentified species. Ailuk: Marab I., *1572,* Ailuk I., *1699;* Mejit, *1454;* Wotje: Riri I., *1760;* Jaluit, *1585, 1587, 1606, 1610, 1614;* Ebon, IX.10.46, *1799.*

When young, and about the margins when mature, formed of distinct minute gelatinous pustules, which later are confluent into a reticular or apparently continuous, uneven-surfaced layer. This inconspicuous but characteristic fungus, originally described from southern Brazil, has since been reported as occurring more generally in tropical America and in the eastern and central states at least as far north as Wisconsin and Massachusetts. It certainly occurs and has been reported (under other names) in western Europe, and has several times been collected in Hawaii.

Four of the specimens here listed are in all respects quite typical, and are not distinguishable from Iowa material. The five

collections made on Jaluit, however, show in varying degrees a more luxuriant growth; the separate lenticular or tuberculiform basidiocarps are confluent to form not merely a reticulate aggregation, or the thin film which seems to be the most homogeneous fructification developed in temperate lands, but a tough, separable membrane, held together by a dense subicular layer, almost cartilaginous in consistency, of conglutinate hyphae. In some of the specimens this layer on drying has remained intact, forming a hyaline, translucent pellicle, glistening (under the binocular) from light reflected from the sides of the minute polygonal areoles which represent the originally separate basidiocarps, and from their very short narrowed stipe-like bases, which remain separate even in the older parts of the fructification, and which can be made out through the continuous surface. The spores and basidia of the Jaluit material also average somewhat larger than those of most other specimens. There is, however, considerable overlapping in these as in other respects; the best developed of the Jaluit specimens is well matched by one from Hawaii, while the more delicate specimens or areas are not distinguishable from some of the Hawaiian and North American ones. It is certain that conditions of temperature and humidity on Jaluit at the time of collection were extremely favorable for the development of tremellaceous fungi, and to the weather may be ascribed the extreme forms here noted.

26. GUEPINIA SPATHULARIA (Schw.) Fries; Coker, Elisha Mitchell Sci. Soc. Jour. 25: 177, pl. 23, fig. 14; 51; 64, fig. 5, 6, 9, 1920; Brasfield, Amer. Midland Nat. 20: 221, pl. 3, fig. 64–66, 1938; Lloydia 1: 155, 1938; Martin, Iowa Univ. Studies in Nat. Hist. 18 (3): 30, 1944. *Merulius Spathularia* Schw., Naturf. Gesell. zu Leipzig Schr. 1: 92, pl. 2, fig. 1–3, 1822.

On bare wood, or growing out through fissures in the bark, of *Pandanus* sp. Utirik, *1554;* Ailuk: Marme I., *1750;* Mejit, *1440, 1453, 1508.*

Guepinia Spathularia as here treated includes all those fungi with fructifications cartilaginous-gelatinous in consistency, orange or brownish-orange in color, flabelliform or incised-flabelliform, tomentose on the compressed stipe and one surface of the expanded summit, with forked basidia and one-septate spores. All of the Marshallese collections have the basidiocarps less obtuse at the distal margin, more translucent, brighter (and redder) in color, and less tomentose on the sterile surface, than any material at hand from temperate regions, and than any shown in the illustrations cited. Microscopically, although the spores may be slightly more slender, no significant differences appear to exist. A considerable number of species have been described from the tropics, most of them differing little from *G. Spathularia.* Several recent authors have indicated doubt of the autonomy of certain or all of these species; and it seems neither necessary nor prudent, in the absence of any considerable amount of tropical material for comparison, to attempt at present a decision on the distinctness of these segregates or of the Marshall Islands material.

27. AURICULARIA AMPLA Pers. in Gaudichaud, Bot. Freycinet Voyage autour du Monde . . . Uranie et . . . Physicienne 177, 1827. *Exidia ampla* (Pers.) Lév., Ann. Sci. Nat. Bot. 3 ser. 5: 159, 1846. *Hirneola ampla* (Pers.) Fries, K. Vetensk. Akad. Handl., 1848: 146, 1849.

Fructifications when fresh thin, flexible, leathery-gelatinous, the dorsal surface uniformly pilose, cinereous-gray, -pink, or -buff, or in old specimens fuscous, glabrescent, the hymenial surface more or less pruinose, dull flesh-color, purplish-rosy, dull purplish, or in older specimens blackish; solitary or gregarious to densely imbricate-caespitose, eccentrically peltate or sessile by a narrowed posterior margin or produced into a short stipe-like sterile base, up to 5 (rarely –20) cm. in breadth, convex and even or slightly plicate above, cupulate and even or in larger specimens shallowly venulose below; when dry thin, flexible, quite fragile, trans-

lucent, pallid-cinereous to buffy-cinereous above or in old specimens sometimes dark and nearly glabrous, below purplish-black to slaty-black, contracted and usually considerably wrinkled; in section composed of a hymenial layer about 70 μ thick, a medullary layer about 700 μ thick, and a compact dorsal layer about 20 μ thick underlying the tomentum; hymenial layer consisting of densely compacted basidia, of paraphyses 1.5–2 μ in diameter with brownish branching indistinct tips exceeding the basidia and forming a dense continuous superficial layer, and of slender contorted subhymenial hyphae; medullary layer of rather loosely arranged hyphae with irregular often open clamps and confluent, highly gelatinized walls, apparently 2–3 μ in diameter but much thicker if the limits of the walls could be observed, mostly parallel to the surface in the middle and perpendicular in the upper and lower quarter; dorsal layer consisting of an inner colorless half of heavily stainable hyphae 1 μ in diameter, densely compacted, perpendicular to the surface, and with little gelatinized wall material between, and an outer pigmented layer abundantly penetrated by the bases of the surface hairs; hairs up to 225 × 4.5–7 μ, thick-walled and aggregated in conical tufts; basidia linear or slightly clavate, 40–50 × 4.5–5 μ, 3-septate; spores allantoid, 15.5–17 × 4.5–5.5 μ.

In the Marshalls usually on wood of *Cocos nucifera,* with one collection on *Artocarpus incisus.* Wotje: Ormed I., *1353, 1354, 1379, 1383;* Namu: Namu I., *1404, 1414, 1434;* Ebon, *1338.*

A thin, leathery, often ear-like basidiocarp, pilose and ashy to nearly glabrous and brownish-black above, and rosy to purplish-black below. The most abundant growth was encountered on Ormed, where large clusters had developed on standing dead trunks of coco palms, many of which had been topped by the blockaded Japanese garrison for their edible terminal buds, while others had been cut by artillery fire or bomb-blast. The Marshallese name, "lajiling kijilik" (rat's ear), is applied without much discrimination to many bracket- or ear-like or even stipitate Basidiomycetes—polypores, *Pleurotus,* and others—but there was some suggestion that this species is the true rat's ear, and on Ormed the name was given only to this *Auricularia.* Strangely enough, it is not eaten in the Marshalls, whereas in Hawaii the same species, under the name "pepeiaoakua" (ghost ear) is regarded, not mistakenly, as good food.

Persoon's description (*loc. cit.*) reads as follows:

> A[uricularia] magna resupinata substipitata, inferne pubescens lutescente-grisea, superne laevis nigricans. Pers.
>
> In insulis Mariannis inque Moluccis.
>
> Pour la configuration et la couleur, cette espèce ressemble beaucoup à l'*auricularia sambuci* [i.e., *A. auricularis* (S. F. Gray) Martin, Amer. Midland Nat. 30: 81, 1943]; mais elle s'en distingue par sa partie fertile, qui n'est presque pas veineuse, et parce qu'elle pousse en-dessous une sorte de *stipes* ou appendice long de quelques lignes. A ces caractères, il faut ajouter l'*habitat,* qui pourtant ne doit pas avoir influé sur la forme et la dimension? P.

In this there is, first of all, an obvious error: the description has the basidiocarp inverted; it is not pubescent below, but above. (It may be noted that Fries and succeeding generations of mycologists made the same mistake for all species which, like this, were placed in the genus *Hirneola.* See Fries [*loc. cit.*], p. 144; and 1825: 93.) The presence of a stipe, furthermore, is here no more than fortuitous; it is not a discrete structure, but an indistinct prolongation of the basidiocarp, and probably no more than an occasional response to the position of the latter, or to such an external condition as development through a fissure in the bark. The same development occurs in northern specimens of *A. auricularis.* Neither is the configuration of the hymenium a constant character; among the numerous collections at hand some are quite smooth, and others as venulose, and as ear-like in their convolutions, as any specimen of *A. auricularis.* The word "resupinata" need not be misleading if it be noted that Persoon (1822: 97) uses the same adjective in describing the familiar northern *A. auricularis.* What is left, then, of Persoon's account is a description of a large species of *Auricularia,* yellowish-gray-pubescent above, blackish below, greatly resembling *A. auricularis,* and occurring from

the Marianas to the Moluccas. The size of the Marshalls specimens is not remarkable, nor does the largest specimen at hand, a Hawaiian basidiocarp 20 × 12 cm., significantly exceed the maximum given by Martin (1944: 65) for *A. auricularis*—which, as it happens, is also described by Persoon as "sat magna"; but the typical development of the tropical fungus seems to be a larger one. The yellow-ashy dorsal surface and blackish hymenium are characteristic of mature specimens, grown in strong light, of the form under discussion, which is probably the one *Auricularia* of the Pacific islands resembling *A. auricularis*. Whether the two are distinct has been doubted; probably reports of *A. auricula-judae* from Oceania, such as Hennings's, cited earlier, and Patouillard's, refer to the fungus here called *A. ampla*. By its more strongly pilose basidiocarps, conspicuously rosy young hymenia, and somewhat larger spores it is at least readily distinguishable, and one inclined to question the distinctness of the Pacific form should note that the differences are much greater in living than in preserved material. Unsatisfactory as it is, Persoon's account gives as sound a basis for the identification of his fungus as do those of later authors whose names have been more commonly adopted. Briefly, that basis is an abbreviated description which, allowance being made for obvious error, is quite applicable, as far as it goes, to the fungus at hand, and with that description a geographical limitation which seems to confine the application to the one species. Reference to the original valid descriptions of accepted species of *Auricularia* will show that they are no better founded. It is at least highly probable that the form under consideration is *A. ampla,* and that name should be superseded only if reason appears to doubt the correctness of its application, or if an earlier name, likewise probably applicable, exists.[4]

Dried mature specimens from the Marshalls mostly show on the dorsal surface a color that cannot be exactly matched in Ridgway—more tawny, and less greenish, than Olive-Buff or Deep Olive-Buff; the grayer specimens are Pale Olive-Gray to Mouse Gray; the hymenium is Light Quaker Drab to Blackish Plumbeous. A specimen soaked for spore-printing (and still alive) showed the hirsute surface Pallid Mouse Gray and Light Mouse Gray to a tawny color like that of the dried material, and the hymenium Light Heliotrope-Gray to Dark Purple-Drab, Dark Vinaceous-Gray, and Heliotrope-Slate; certainly young specimens were redder when first collected. Freshly collected Hawaiian specimens have the dorsal surface Tilleul Buff and Vinaceous-Buff to Sorghum Brown, Drab-Gray, and Drab, and the hymenium Russet-Vinaceous to Sorghum Brown. The colors of the very brightest young hymenia have not been recorded; according to my recollection they

[4] Through the great kindness of Dr. A. J. Lam and R. A. Maas Geesteranus of the Rijksherbarium, Leiden, I have recently (II.18.47) been permitted to study adequate fragments of the type of *A. ampla* and a photograph of the entire type collection. The two fructifications there present measure respectively 4.5 × 3.5 and 8 × 7 cm.; the dorsal surface is evenly pilose, and Cinnamon Brown to Prout's Brown (Mr. Maas Geesteranus writes that the smaller specimen is glabrescent); the ventral surface is nearly smooth (only a few low folds appearing in the photograph), not pruinose, and Plumbeous Black or Black. The layers shown in section are the same as those here described in the Marshalls material except that for about 75 μ above the basidia the medullary layer includes a continuous mass of colorless, amorphous, refractive material not seen in any Marshalls specimen sectioned. Persoon's type and the Hawaiian and Marshall Islands specimens agree very closely, and their identity may be considered to be established. The name *A. ampla* which heads this note cannot, however, be retained; it is antedated by *Exidia cornea* (Ehrenb.) ex Fries, Syst. Mycol. 2: 222, 1822 (*Auricularia cornea* Ehrenb., Hor. Phys. Berol. 91, pl. 19, fig. 9, 1820), a name applied to the same fungus collected on Oahu by Chamisso. The valid name is then *Auricularia cornea* ([Ehrenb.] ex Fries) Ehrenb. ex—. I have been unable to find that this binomial has been validly published; it seems unlikely that a still earlier name will be discovered.

The type of *A. ornata* is now lacking at Leiden.

would be at least as red as Purplish Vinaceous.

28. AURICULARIA ORNATA Pers. in Gaudichaud, Bot. Freycinet Voyage autour du Monde . . . Uranie et . . . Physicienne 177, pl. 2, fig. 4, 1827. *A. adnata* Lyon in Rock, Hawaii Coll. Publ. Bul. 4: 33, 1916.

Fructification when fresh tough fleshy- to cartilaginous-gelatinous, adnate over much of its area or centrally peltate-rooting, disciform, lobed-disciform, or by confluence elongate, 0.5–7.5 cm. in diameter, the margins at first closely appressed, later often reflexed to 0.5 cm., the lower (hymenial) surface pruinose, soft brown (Pale Brownish Drab to Natal Brown), in young specimens smooth to slightly rugose, in older with strong, irregularly forking, vein-like thickenings more or less radially arranged, the upper surface where free coarsely pilose, zonate, the zones alternately of long and of short hairs, mostly dark brown (Snuff Brown to Bister), but interspersed with light bands (about Pinkish Buff), in young specimens with appressed margins the pilosity shown only as a narrow buffy margin; when dry hard, in consistency like dried cartilage, the hymenium strongly pruinose, plumbeous (Cinereous to Dark Plumbeous), with younger portions lighter and browner (Drab-Gray); in section composed of a hymenial layer about 85 μ thick, a medullary layer about 1000 μ thick, and an abhymenial layer about 30 μ thick; the hymenial layer consisting of a pigmented superficial portion about 15 μ thick composed of the indistinct, branching ends of paraphyses 1–1.5 μ in diameter, and a basidial portion; the medullary layer consisting of hyphae 3–9 μ in diameter with irregular, often open clamp connections and greatly gelatinized walls, densely compacted and perpendicular to the surface in the lower and upper 100 μ, looser and more or less parallel to the surface in the middle; the abhymenial layer brown, nearly opaque, compact and (in the free parts of the basidiocarp) supporting a pilose layer about 70–300 μ thick (according to the surface zonation) of free brown hyphae; basidia linear or often narrowly claviform or basally ventricose, 3-septate, 52–70 $\times$ 5.5–7 (rarely –8.5) μ; spores thick-allantoid, with stout truncate apiculus, 12.5–15.5 (–17) $\times$ 5.5–6.5 μ.

On bark and decorticate wood of *Messerschmidia argentea.*

LINE ISLANDS (Pacific): Palmyra I., VIII.20.24, *H. F. Bergman* [*A*], [*B*], det. by Lyon as *A. adnata.*

MARSHALL ISLANDS: Utirik, *1549;* Ailuk: Marab I., *1568,* Ailuk I., *1518;* Wotje: Riri I., *1372;* Namu: Leuen I., *1408.*

A leathery growth, brown above and below when moist and active, apparently limited to the single substratum *Messerschmidia* (=*Tournefortia*) *argentea,* and to hard, elevated, little decayed branches of that species. The earliest of the Marshalls collections was made in a soaking rain, and the fungus was at first taken to be a somewhat thicker and softer relative of *Stereum hirsutum.* The highly characteristic brown color disappears from the hymenium on drying, and is replaced by a pruinose slate not too different from the appearance of other species of *Auricularia.* Since *A. ornata* is one of the far too numerous lost species, the original description is here reproduced:

A[uricularia] pileo dimidiato reflexo tomentoso, zonis fuscis pallidisque variegato, inferne venoso nigricante. Pers.

In insulis Mariannis.

Cette plante est l'une des plus jolies espèces du genre. Elle a par sa partie supérieure quelque similitude avec l'*auricularia mesenterica,* Pers. Mycol. Europ. 1, p. 97. Mais sa surface inférieure est garnie de veines comme dans l'*auricularia sambuci* (*tremella auricula,* Linn.). P.

The illustration shows a dimidiate basidiocarp with prominent zonation on the dorsal surface, more like a sketch of *Coriolus versicolor* than like any *Auricularia,* and certainly not remotely like the almost resupinate fungus on *Messerschmidia.* But having soaked a dried specimen to secure a spore-print, I happened to pick away a few marginal bits of the bark to which it was attached, in order to discover how much of the dorsal surface was free from the substratum. The surface revealed was zonate not merely because of the varying lengths of the hairs which covered it, but "variegated by fuscous and pallid bands," exactly as described and illustrated by Persoon. It seems likely that the material from which the description was drawn up either had been removed from its substratum by the collector or had been pried away, as was mine, to discover the character of the dorsal surface. The resemblance noted to *Auricularia mesenterica* may possibly ac-

count for some of the reports of that species from Pacific lands. Fries (1838: 555) lists *A. ornata* as a possible synonym of *A. mesenterica,* with the note, "sec. Montagn. non differt" (Montagne having, it would appear, studied Persoon's specimens). Material at hand of *A. mesenterica* shows a much thicker and more deeply pilose basidiocarp, with the hyphae of the medullary layer much more highly gelatinized and more widely spaced, and with an ochraceous, rather than chiefly brown, dorsal surface. The two species are undoubtedly closely related; on the basis of available specimens, I should consider them amply distinct. There seem to be no zonate species described in the genus other than *A. mesenterica* and *A. ornata;* the latter is as well characterized as any member of *Auricularia,* and there can be little doubt that the collections here cited belong to Persoon's species.

The fungus is quite as certainly Lyon's *Auricularia adnata.* The type of that species, collected "on *Tournefortia* trees" on Palmyra Island, 1,100 miles south of Oahu, is not at hand; but Dr. H. L. Lyon has recently confirmed Bergman's identification of the two later Palmyra collections (from the same substratum), indicating that the specimen now marked "A" is the more typical. These are indistinguishable from the Marshall Islands material. Other adnate species have been described in *Auricularia;* of these only *A. peltata* Lloyd seems well enough characterized to be recognizable without special study. Material at hand of this species shows uniformly smaller and more strongly venulose basidiocarps attached over nearly all the dorsal surface by the uniformly pallid tomentum; it is quite a different fungus from *A. ornata.* It is at least odd, if not significant of relationship, that Lloyd's type, as well as one of the specimens more adequately described by Ahmad (1945: 242) grew on *Cordia "myxa"*—like *Messerschmidia,* an arborescent member of the Boraginaceae.

29. SEPTOBASIDIUM sp. (BOGORIENSI affin.); cf. Boedijn and Steinmann, Buitenzorg Jard. Bot. Jour. 3 ser. 11: 205, fig. 25, 26; pl. 18 (b), (c), 1931; Couch, Genus Septobasidium 213, pl. 61, fig. 3–10; 103, fig. 4–7; 104, fig. 10–12, 1938.

On living prop roots, and more rarely on bark of living trunks, of *Pandanus pulposus* and *Pandanus* spp. Namu: Namu I., *1421,* Leuen I., *1417;* Ailinglapalap, *1480;* Jaluit, *1474, 1577, 1578;* Ebon, IX.9.46, *1335, 1336, 1389.*

This fungus formed conspicuous lichen-like encrusting patches, light gray or lilaceous-gray, on a considerable part of the *Pandanus* trees on the islands where it occurred; the quantity of material collected was limited only by the time that could be profitably spent cutting it off the trunks, and the space available for drying. Although superficially resembling the grayish lichens which occurred abundantly in the same places, the *Septobasidium* could readily be recognized as a member of that genus by the irregular discontinuous development of its margin, by the evident elevation of its surface on short brownish pillars (whereas the lichens clung closely to the bark), and by the brown centers of the older fructifications. It occurred on all the islands visited south of Kwajalein; whether it is found there also is not known, since the two islets of Kwajalein Atoll on which the party landed were almost completely denuded of native vegetation. Although a careful search for the *Septobasidium* was everywhere made, none was discovered north of Kwajalein. On the drier atolls, such as Ailuk and Wotje, where the lichen incrustation was also sparse or wanting, this lack was to be expected; but although on Mejit the vegetation and lichens indicated a climate fully as favorable for the growth of fungi as that of Namu, the *Septobasidium,* it seems safe to say, does not occur there. Some reported hosts of *S. bogoriense,* such as *Citrus* and *Hibiscus,* grow on islands where

Septobasidium was abundant on *Pandanus,* but the fungus was found on none but the latter plant. Parts of all collections have been sent to Dr. J. N. Couch, who will discuss the fungus in a future publication of his.

30. PELLICULARIA ISABELLINA (Fries) Rogers, Farlowia 1: 99, 1943. *Hypochnus isabellinus* (Fries) Fries; Burt, Mo. Bot. Gard. Ann. 3: 222, fig. 12, 1916. *Tomentella isabellina* (Fries) Höhn. and Litsch.; Bourd. and Galz., Hym. Fr. 482, fig. 121 [1928]. *Botryobasidium isabellinum* (Fries) Rogers, Iowa Univ. Studies in Nat. Hist. 17: 11, pl. 2, fig. 5, 1935.

On wood, husks, and dead leaf-sheaths of *Cocos nucifera,* and on old polypore. Ailuk: Ailuk I., *1758;* Mejit, *1443, 1512;* Likiep: Eniarmij I., *1690;* Namu: Leuen I., *1419;* Jaluit, *1604.*

A delicate ochraceous tomentose growth, under the lens minutely tufted, under the microscope composed of stout, short-celled hyphae branching at right angles, of rough-walled subglobose spores, and of obpyriform basidia. The mature spores are thin-walled when abstricted; but in the Namu specimen, and to a slighter extent in others also, the wall soon becomes considerably thickened. I have seen one other similar tropical collection.

31. PELLICULARIA LEMBOSPORA Rogers, Farlowia 1: 109, fig. 8, 1943.

On bark of rotten log of *Ochrosia parviflora.* Likiep: Biebi I., *1672.*

A cream-colored, very slight and loose, hypochnoid growth; distinguishable under the microscope by its small navicular spores mostly 7–8 × 3 μ. The collection consists of a few minute pallid patches of this, the perfect stage, scattered among the much more robust, tawny, imperfect fructification of the same fungus. See under *Oidium tomentosum,* below. Previously reported from British Guiana and Cuba, and present also in Hawaii; a tropical relative of the more nearly ubiquitous *P. vaga.*

32. PELLICULARIA VAGA (Berk. and Curt.) Rogers, Farlowia 1: 110, fig. 9, 1943. *Corticium botryosum* Bres.; Bourd. and Galz., Hym. Fr., 241 [1928].

On bark, wood, and husks of *Cocos nucifera,* and wood of *Pandanus* sp., *Artocarpus incisus,* and an undetermined dicot. Utirik, *1459, 1801;* Ailuk: Ailuk I., *1703, 1746, 1757;* Mejit, *1447, 1448, 1510, 1515, 1520;* Likiep: Likiep I., *1477;* Wotje: Ormed I., *1370, 1543;* Jaluit, *1615.*

A pallid or buff hypochnoid growth with the characteristic very wide mycelium of the genus and naviculiform spores (fusoid, depressed on one side) mostly 10–12 × 4.5 μ. The commonest member of the genus in the Marshalls, as on the northeastern and northwestern coasts of the American mainland and, apparently, in western Europe.

FUNGI IMPERFECTI

33. HELICOMYCES ROSEUS Link; Linder, Mo. Bot. Gard. Ann. 16: 271, pl. 12, fig. 5–7, 1929.

On husks of *Cocos nucifera.* Ebon, IX.10.46, *1805* (with *1338*).

A grayish bloom, imperceptible except under considerable magnification, composed of hyaline linear conidia coiled like a watch-spring, and very short hyaline conidiophores. The fungus was discovered only when the specimen earlier cited of *Sebacina farinacea* was being examined under the binocular. It is less conspicuous macroscopically than the quite inconspicuous Iowa specimens, determined by Linder, with which it was compared, but agrees in all other respects.

34. OIDIUM TOMENTOSUM (Berk. and Curt.) Linder, Lloydia 5: 204, pl. 5, fig. E, 1942.

On bark of rotten log of *Ochrosia parviflora* and unidentified dicot wood. Likiep: Biebi I., *1672, 1674.*

Pilose, loose, reddish-tawny; composed, as are all species of *Pellicularia*, of very thick, short-celled hyphae branching at right angles; fruiting by globose conidia borne on short peg-like lateral teeth. As in Hawaiian collections, this imperfect stage is much better developed than the perfect stage, *Pellicularia lembospora*. Reported from the Bahamas and Cuba.

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A Chloride and Oxygen Analysis Kit for Pond Waters[1]

R. B. Dean and R. L. Hawley[2]

INTRODUCTION

Fishponds in the Hawaiian Islands are shallow brackish ponds which are frequently fed by underwater springs as well as surface flows of fresh water and sea water. The chloride content of the water is an indication of the quantity of sea water present and is one factor which affects the growth and survival of many of the plants and animals utilized as food by the fish. The presence of dissolved oxygen is absolutely essential for animal life in the ponds. Low oxygen concentrations in some regions indicate stagnant waters and bottom putrefaction which make these areas unfit for fish. In the course of fisheries studies in the Hawaiian Islands it was therefore necessary to make a large number of salinity and oxygen determinations on fishpond waters.

Since both chloride and oxygen may vary severalfold in a single pond, and since most living organisms are insensitive to concentration changes which are less than 1 per cent of the normal value, it is not necessary to make extremely accurate determinations. Methods were desired for the rapid analysis of chloride and oxygen at the side of the pond so that any unusual observations could be checked before one left the pond.

The apparatus described in this paper was designed to provide sufficient equipment and reagents for 25 chloride, and 50 dissolved oxygen determinations. Two auxiliary half-liter bottles contain enough reagents for an additional 50 chloride determinations. Chloride up to 25 gm. per liter (sea water is about 20 gm. per liter) can be determined with an accuracy of 0.06 gm. of Cl per liter. Dissolved oxygen up to 20 cc. per liter can be determined with an accuracy of 0.1 cc. per liter on a sample of 10 cc. of water. The apparatus weighs about 25 lb. and can be used in a rowboat, if necessary. A single chloride determination requires about 3 minutes; an oxygen determination requires about 8 minutes.

Although there are several well-known titrimetric methods for chlorides, none of them is suitable for use on micro-samples out-of-doors where it is difficult to observe a colorimetric end point. An electrometric method of detecting the end point which substituted a galvanometer needle for the color change appeared to be more suitable for our purposes. None of the published electrometric methods was quite satisfactory and an entirely new method was developed which will be dealt with in another publication (Dean and Hawley: unpublished). This method makes use of two wire electrodes, a galvanometer, a few radio resistances, and a dry cell. A relatively low resistance circuit is formed which is not sensitive to high humidities, although it should not be soaked in water.

Krogh (1935: 131–133) has described a modification of the Winkler method for dissolved oxygen which was well suited to our purpose, with slight modifications. Krogh used the conventional starch indicator to detect the end point. We have substituted

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Foulke's dead-stop electrometric end point (Foulke and Bawden, 1926: 2045 ff.), because the starch iodine indicator is unreliable above 25° C. and our field temperatures frequently exceed 30° C. Essentially the same electrical circuit is used for both the oxygen and the chloride end points: only the electrodes are different.

The unknown solutions are titrated with standard solutions from a micrometer syringe burette (see Trevor, 1925: 1111; Dean and Fetcher, 1942: 237; and Dean: unpublished). This burette has many advantages over conventional gravity-feed burettes. It is more compact, there is no drop error and no parallax error, and better than 0.1 per cent accuracy is possible on a total volume of only 1 cc. of reagent. Micro methods are obviously necessary to conserve reagents if a small apparatus is to carry enough to permit 50 or more determinations. Two syringes are used interchangeably with the same micrometer head in this apparatus, so that it is not necessary to clean and refill the burette when changing from chlorine to oxygen analyses.

DESCRIPTION OF THE APPARATUS

All of the equipment is contained in a wooden box which measures $9 \times 9 \times 12$ inches (see Fig. 1). The electrical wiring is enclosed in a mahogany case which is firmly attached to the right-hand side of the box. The galvanometer is a needle type of instrument which has a sensitivity of 0.25 microamperes per scale division and a critical damping resistance of 1,800 ohms.

The electrical circuit is shown schematically in Figure 2. The two switches S_1 and S_2 are combined in a telephone type of toggle switch. In the central position both switches are open and no current flows. When the switch is moved to either side, current flows from the battery through the series of resistors in the upper line. Suitable taps take off about 10,200 and 1,018 mv. to the Pt, Ag, and Standard Cell terminals respectively. Variations in the internal resistance of the dry cell can be compensated for by adjusting resistor R_2 when the switch is thrown to the left. In this position the voltage of the standard cell opposes a fraction of the voltage from the battery. Resistor B is adjusted until no current flows through the galvanometer. In actual practice it has been found that the voltage from a flashlight dry cell does not change significantly, even when the circuit is left open for 2 days. It would have been satisfactory to omit the standard cell and variable resistor B entirely. The potential at the chloride electrodes could be checked before each series of measurements, as is described below.

The electrodes are constructed as shown in the insert of Figure 2. Short pieces of silver or platinum wire are attached to stiff bronze wire with hard solder. The wire electrode is then sealed in a straight glass tube. It is not difficult to seal platinum into soft glass. Silver wire of 22 gage can also be sealed into soft glass but some of the seals break soon after sealing. After the glass is sealed onto the electrode wire, both the glass tubing and the bronze wire can be bent in the ordinary manner, since bronze wire softens at red heat.

The stiff bronze wire is passed through a hole drilled in a small radio jack plug as indicated in the diagram. The four electrode leads—Ag, Cu, and two Pt—are brought to jacks on a mounting plate at the left end of the box under the end of the burette. When either pair of electrodes is plugged into its corresponding jacks, the electrode wires just reach the center of the titration vessel. The Ag and Cu jacks are further differentiated by color to reduce the danger of inserting an electrode in the wrong terminal.

The micrometer-syringe burette consists of a 1.5 cc. glass hypodermic syringe fitted in a frame to which is attached a 1-inch machinist's micrometer graduated in 1,000 parts. The burette assembly is described fur-

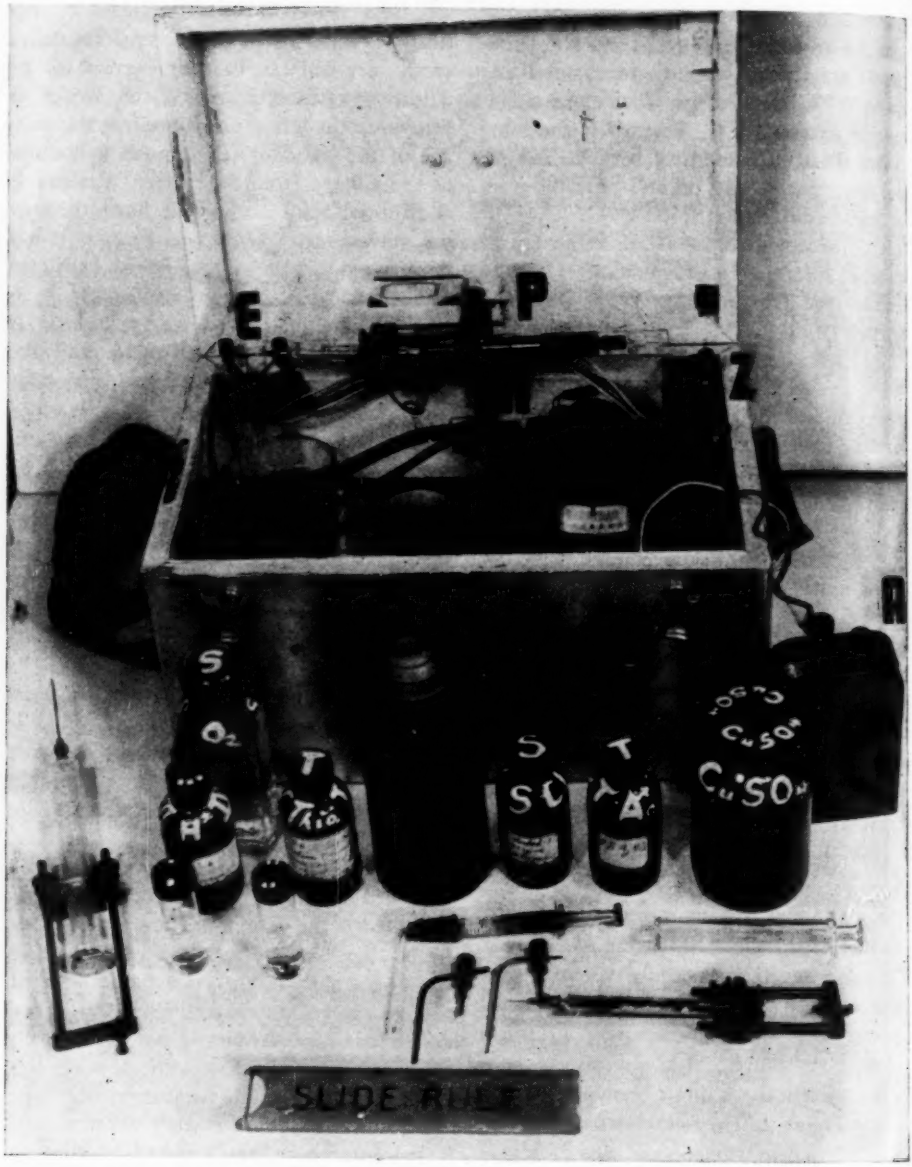

FIG. 1. Analysis kit for chloride and oxygen. Chloride reagents and syringes to the right; oxygen reagents and syringe to the left. *E*, electrode holder. The chloride electrodes are just above the slide rule. *P*, micrometer burette with syringe to hold sodium thiosulfate reagent. The silver nitrate syringe is above chloride electrodes. *N*, galvanometer. *Z*, toggle switch. *A*, standard cell. *T*, rubber bulb in bottle of distilled water for washing. The syringes and slide rule fit in clips inside the lid of the box. Most of the equipment remains in the box during the analysis.

ther in Dean and Fetcher (1942: 237; see also Dean: unpublished). For the oxygen determination a solution of thiosulfate is used in the burette and a 2-inch 22-gage hypodermic needle bent downward at 90° serves as the delivery tip. The chloride determination requires a strong solution of silver nitrate, which corrodes all available metals, so that a glass tip must be used. In this apparatus we used a bent glass tube attached to the burette by a number 0 one-hole rubber stopper.[3]

[3]The Ace Glass Company, Vineland, N. J., is now able to supply ground glass tips to order which will fit on a standard hypodermic syringe.

The titration vessel is a shortened test tube about 25 mm. in diameter and 70 mm. long. It fits in a wire test tube holder which is attached to the electrode jack assembly. The burette tip and the two electrodes dip into the solution in the titration vessel. In addition there is a glass tube to introduce air bubbles for stirring. Air is forced by an aspirator bulb into a 1-liter can which serves as an air reservoir, and flows from there through a thin rubber tube to the glass nozzle of the air stirrer. The aspirator bulb can be conveniently squeezed by the left hand of the operator during a titration.

A reagent shelf over the air reservoir

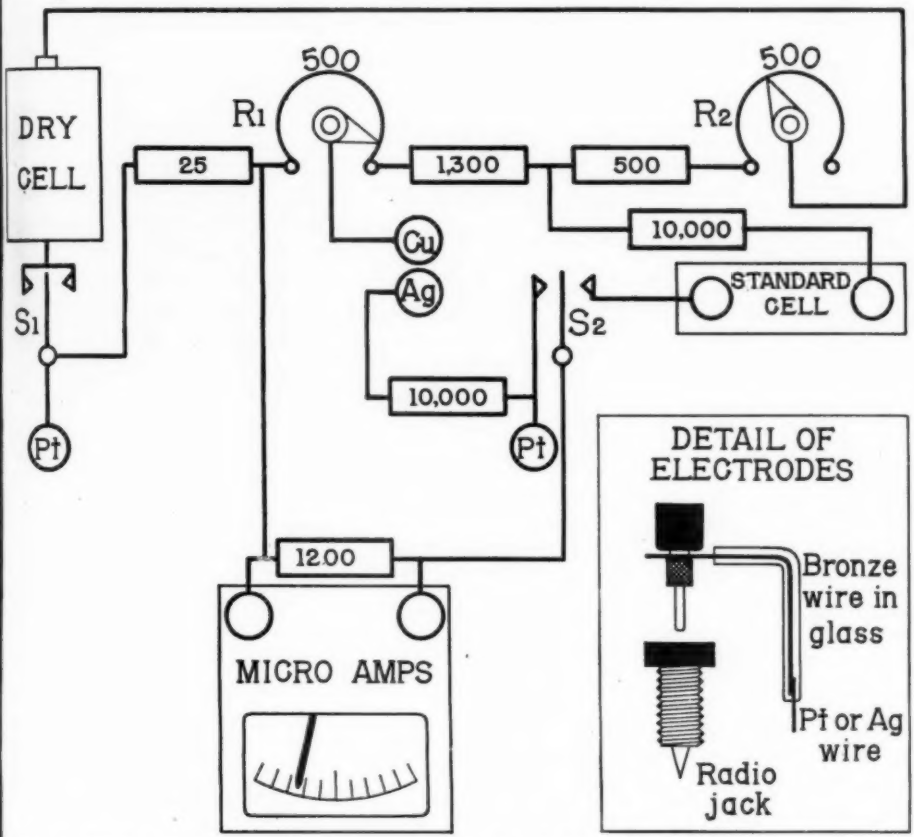

FIG. 2. Wiring diagram. S_1 and S_2 are two parts of a double-pole, double-throw telephone-type toggle switch. Wires run from the Pt, Ag, and Cu terminals to the electrode holder.

holds five 60-cc. screw top bottles and two 10-cc. screw top vials. In addition, there are several larger reagent bottles in the bottom of the box and a bottle of distilled water for washing electrodes and glassware. A glass tumbler is fitted under the electrodes for a waste jar. A rubber ear syringe is fitted with a glass delivery tip bent at an angle of 135°. This syringe can be filled from the distilled water bottle and the water in it then directed in a stream into the inverted titration vessel or onto the electrodes to clean them.

The reagents are all contained in screw cap bottles or vials. The screw caps are lined with Polythene, which is resistant to all the reagents used in this work. Two of the vials are fitted with rubber disks from 10-ml. penicillin bottles. The disks are held on by screw caps which have been drilled with ¼-inch holes. The rubber disks on the vials can be repeatedly perforated by a hypodermic needle and the reagents withdrawn through the needle.

All the reagents and equipment used for the chloride analysis are marked with black paint and the various reagents are identified by white letters on the top, as well as by conventional labels on the sides of the bottles. The reagents and apparatus for the oxygen determination are likewise marked with red paint and white letters. The metal parts of the syringe pipettes and the burette are of brass which was first dulled by a dip in silver nitrate and nitric acid, and then coated with Glyptal varnish which was baked on. This treatment produces a non-glaring, corrosion-resistant surface. The syringes are attached by clips to the inside of the top of the box. A small box of filter paper squares, about 3 cm. on a side, which are used to wipe the burette tips and the electrodes, is also attached inside the top of the box. A rubber stopper is screwed inside the top at the right-hand side in such a way that the lid will not close until the switch has been turned off. This arrangement insures that the battery will not be left on when the box is closed.

CHLORIDE ANALYSES

The chloride analysis depends upon the fact that the potential of a silver electrode changes rapidly when all the chloride ions have been precipitated by silver ions. Since it is impossible to measure a single electrode potential, another electrode which is not sensitive to chloride ions must be present to complete the circuit. We have used a copper electrode in the presence of nearly saturated copper sulfate. The potential between these two electrodes is about 200 mv. at the end point. The potentiometer circuit supplies 200 mv. between the Cu and Ag electrodes and, at the end point, no current will flow through the galvanometer.

Before the end point is reached the potential between the electrodes will be less than 200 mv. and the galvanometer will be deflected to the right. There is a large protective resistance in series with the chloride electrodes so that the galvanometer may be left continuously in circuit. As the end point is approached the galvanometer needle approaches zero and is deflected to the left as soon as the end point has been exceeded. The deflection produced by the addition of one or two burette divisions of silver nitrate is greatest at the end point. This fact can be used to set the potentiometer to the correct potential. The potentiometer is adjusted until the galvanometer indicates zero. The galvanometer deflection is then noted after the addition of two burette units of silver nitrate. This procedure is repeated until the galvanometer deflection is a maximum. The potentiometer is left at this setting for subsequent titrations.

The silver nitrate reagent contains 4 per cent silver nitrate and 0.5 per cent nitric acid. The burette is filled by bringing the reagent bottle of silver nitrate, marked with a T on a black screw cap, up under the burette tip. The plunger of the syringe is withdrawn by unscrewing the micrometer, and silver nitrate is sucked into the syringe.

Any air bubbles are displaced by rotating the burette in its clamp until the tip is upwards and then forcing a little of the silver nitrate reagent out of the tip. The burette is filled up to the 1,000 mark on the micrometer and the tip rinsed with water.

Ten cc. of saturated copper sulfate is placed in the titration vessel; a syringe with tip broken off is used to make the transfer. Commercial bluestone can be used for this solution, although it may introduce an undesirably high blank. Reagent grade copper sulfate is perfectly satisfactory. The copper sulfate solution is placed under the electrodes and the air stirrer is started. A small residual concentration of chloride ions may produce a galvanometer deflection to the right. If it does, silver nitrate is added until the galvanometer reads zero. The burette reading is recorded. The chloride sample, about 0.4 cc., is then introduced from a precision syringe pipette (Krogh, 1935: 130; Dean: unpublished). Silver nitrate is added until the galvanometer again indicates zero and the second burette reading is recorded.

Neither the exact volume relations of the syringes nor the concentration of the silver nitrate need be known exactly. All these are evaluated as a single factor by titrating the same volume of a known standard solution of sodium chloride which contains exactly 20 gm. of chloride ions per liter.

When the galvanometer has been brought to zero a second time and the burette reading has been recorded, the air stirrer is removed and wiped. The burette is tipped up and the tip is wiped and the burette is refilled. The electrodes and the burette tip are rinsed and the apparatus is ready for the next determination.

The errors are of the order of 1 burette division or 1 part in 800. Greater precision could be obtained by precipitating most of the chloride in a larger sample with silver nitrate from another pipette. A more dilute solution of silver nitrate could then be used in the burette. It might be advisable to carry out such determinations in more dilute solutions to avoid too much clumping of the silver chloride precipitate. The accuracy is limited by the reproducibility of the syringe pipettes. Krogh (1935: 130) reports an accuracy of 1 part in 10,000 and we have several syringes with an accuracy of 2 parts in 10,000.

OXYGEN ANALYSES

Oxygen is determined by its reaction with a solution of manganous hydroxide to form manganic oxides. When all the oxygen has been absorbed, the solution is made acid and the manganic ions react with iodide ions to liberate free iodine. The iodine is titrated with sodium thiosulfate in the presence of two bright platinum electrodes. A potential of 10 mv. is applied between these electrodes and a current will flow as long as there is iodine in the solution to remove electrons from the negative electrode. As soon as all the iodine has been removed the current ceases to flow, except for a very small residual current. As the end point is approached, the galvanometer deflection decreases from the left and the end point is taken when the galvanometer indicates one unit deflection to the left.

A 10-cc. syringe pipette (Krogh, 1935: 132; Dean: unpublished) is fitted with a 2-inch 18-gage stainless steel needle. An aluminum cam cemented to the plunger with Varno cement will engage a stop on the side of the syringe holder when the syringe holds 10 cc. An additional 0.2 cc. can be introduced by rotating the cam away from the side stop and pulling back until the plunger reaches an end stop.

The syringe is first rinsed with Solution I. This solution is made up by dissolving 90 gm. of NaI and 40 gm. of NaOH in 55 cc. of water (Pomeroy and Kirschman, 1945: 716) and all air bubbles are expelled. This

reagent is kept in a small rubber-capped vial marked on each side with one white dot. The needle of the syringe is inserted into the vial and the vial is inverted while the solution is drawn in and the air bubbles are expelled. This leaves about 0.1 ml. of solution in the dead space of the syringe. The water sample is then drawn into the syringe until the cam on the plunger reaches the side stop. The needle is then inserted into a second vial, marked with two white dots, which contains Solution II. This solution is made from 40 gm. of $MnCl_2$, 10 cc. of 6N HCl, and enough water to make 100 cc. This solution is drawn into the syringe by moving the plunger from the side to the end stop.

The manganous chloride reacts inside the syringe with the sodium hydroxide which was left in the dead space, to produce a light fluffy precipitate of manganous hydroxide. This precipitate absorbs oxygen, and in 4 minutes substantially all of the oxygen will have been absorbed. The contents of the syringe are then discharged below the surface of 1 cc. of 6N HCl in the titration vessel. The syringe is rinsed first with the acid solution to dissolve any manganous hydroxide remaining in the syringe, and then with two small portions of water from a spare titration vessel. The 6N HCl is contained in a 60-cc. bottle fitted with a rubber medicine dropper. One dropper full is about 1 cc.

The titration vessel now contains iodine equivalent to the oxygen which was present in the water. The iodine is titrated with a sodium thiosulfate solution. This solution must be made up fresh every week by diluting to 60 cc. one medicine dropper full of a 60 per cent solution of sodium thiosulfate containing 1 per cent borax. This concentrated solution is quite stable. Most of the iodine is discharged with thiosulfate from the burette before the air stirrer is started, because the air might otherwise remove some of the iodine.

The thiosulfate solution and the volumetric apparatus are standardized by the use of a standard solution of KIO_3. This solution is 0.0004167 molar and is equivalent to 14 cc. (STP) of oxygen per liter. The dead space of the syringe is first filled with Solution I. The syringe is then rinsed with acid contained in the titration vessel and filled with the standard iodate solution. The iodate reacts with the iodide and acid to liberate iodine in the syringe. The iodine is titrated with thiosulfate, and the burette difference which is found corresponds to 14 cc. of oxygen per liter. Blank runs on water which had been freed of oxygen by hydrogen and platinized asbestos showed that the end point and other errors are less than 0.1 cc. of oxygen per liter.

The oxygen concentration is calculated in essentially the same manner as that used for the chloride. The initial burette reading is always taken as 1,000. This procedure introduces a small constant error of the order of magnitude of 0.1 cc. of dissolved oxygen per liter.

SUMMARY

A portable apparatus which is equipped for the determination of chlorides and dissolved oxygen in pond waters is described. The chloride is determined by a new electrometric method. Oxygen is determined by a modified Winkler method and the iodimetric end point is detected electrometrically. The volumetric apparatus consists of precision syringe pipettes and a micrometer burette. Up to 25 gm. of Cl per liter can be determined with an accuracy of 0.06 gm. per liter. Up to 20 cc. of dissolved oxygen per liter can be determined with an accuracy of 0.1 cc. per liter. Greater precision over a smaller range of chloride concentration is possible, since the syringe pipettes can attain an absolute accuracy of one part in 10,000.

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A New Species of Carex (Cyperaceae) from Fiji: Pacific Plant Studies 6[1]

HAROLD ST. JOHN[2]

INTRODUCTION

CAREX IS THE LARGEST GENUS of the Cyperaceae, having well over 1,000 species. This genus of sedges is abundantly represented in the Arctic and Temperate Zones of the Northern Hemisphere. In the Tropics there are but few species. The genus extends to the continents of the Southern Hemisphere, but the representation there is meager. In the tropical Pacific, some islands support a very few species, while the others entirely lack the genus. In view of this distribution, it is of interest to announce a newly discovered species from Fiji.

A NEW FIJIAN CAREX

Carex vitiensis St. John, sp. nov. Fig. 1.

Rhizomatis breve caespitosis lignosis, culmis 9–10 dm. altis erectis nudis trigonis glabris striatis, laminis multis 7–8 dm. longis 4–6.5 mm. latis pallide viridibus longe acuminatis glabris striatis marginibus scabris, vaginis brunneis omnibus laminiferis, inflorescentiis 45–55 cm. longis 1–1.5 cm. latis interruptis, nodis 6–8, bracteis foliaceis ocreis anguste cylindricis inferis 4–6 cm. longis, laminis inferis 3–4.5 dm. longis, nodis 5–14-spiculiferis, spiculis adscendentibus androgynis lateralibus 2–6.5 cm. longis 1.5–3 mm. latis, pedunculis 1–11 cm. longis filiformibus scaberulis, floribus masculis paucis ad apicem spicorum, squamis foemineis 2.2–3.2 mm. longis obovatis nervosis glabris costis viridibus marginibus hyalinis albidis apice mucroniferis, utriculis 4.8–5.2 mm. longis 1–1.2 mm. latis trigonis breve hirsutulis viridescentibus lateris plerumque valde trinervosis corporibus anguste fusiformibus, stigmatis 3, stylo incluso, achaeneis 2.7–3 mm. longis lucidis stramineis trigonis corporibus anguste ellipticis lateribus canaliculatis ad basim cuneatis ad apicem et basim styli durescentibus contractis.

Forming dense clumps; rhizome short, densely caespitose, horizontal or descending, woody; culms 9–10 dm. tall, 1.5–2 mm. in diameter, central, erect, naked, sharply trigonous, glabrous, striate, greenish; leaves numerous, shorter than the culms, 7–8 dm. long, 4–6.5 mm. wide, flat, pale green, long tapering, glabrous, finely striate nerved, the margins scabrous; leaf sheaths brown, prominent, all leaf-bearing; inflorescence 45–55 cm. long, 1–1.5 cm. wide, elongate, interrupted, the nodes 6–8; the bracts with the base green, closely sheathing, long cylindric, the lowest one 4–6 cm. long, the others shorter, the blades foliaceous, exceeding their spikes, the lowest one 3–4.5 dm. long; spikes 5–14 at each node, slender peduncled, ascending or the tips slightly diverging; peduncles 1–11 cm. long, filiform, scaberulous; spikes androgynous, the lateral ones 2–6.5 cm. long, with a short staminate apex, the terminal one 2.5–5 cm. long with one or a few pistillate flowers at base; pistillate portion of spikes 1.5–3 mm. in diameter, slender, cylindric, loosely flowered, the ascending perigynia partly imbricate; pistillate scales 2.2–3.2 mm. long, obovate, the back green, the margins hyaline and whitish, nerves numerous, parallel, close, glabrous except for the midrib excurrent into a scabrous awn ⅓ to ¼ the length of the body; staminate scales similar but somewhat narrower and straw-colored; perigynia 4.8–5.2 mm. long, 1–1.2 mm. wide, trigonous, short white hirsutulous throughout, especially on the angles and beak, greenish, strongly nerved, usually with 3 nerves on each side and with marginal nerves, the body slender fusiform, tapering into a slender, rigidly bidentate beak nearly as long, the body with the two outer faces nearly plane, the inner side channeled; stigmas 3; style included; achene 2.7–3 mm. long, smooth, straw-colored, sharply trigonous, with wing-like angles and concave faces, the body narrowly elliptic, tapering to the 0.3 mm. stipitate

[1] This is the sixth in a series of papers designed to present descriptions, revisions, and records of Pacific island plants. The preceding papers were published as Bernice P. Bishop Museum Occasional Papers: 17 (7), 1942; 17 (13), 1943; 18 (5), 1945; Amer. Fern Jour. 35: 87–89, 1945; Torrey Bot. Club Bul. 73: 588, 1946.

[2] Chairman, Department of Botany, University of Hawaii. Manuscript received November 13, 1946.

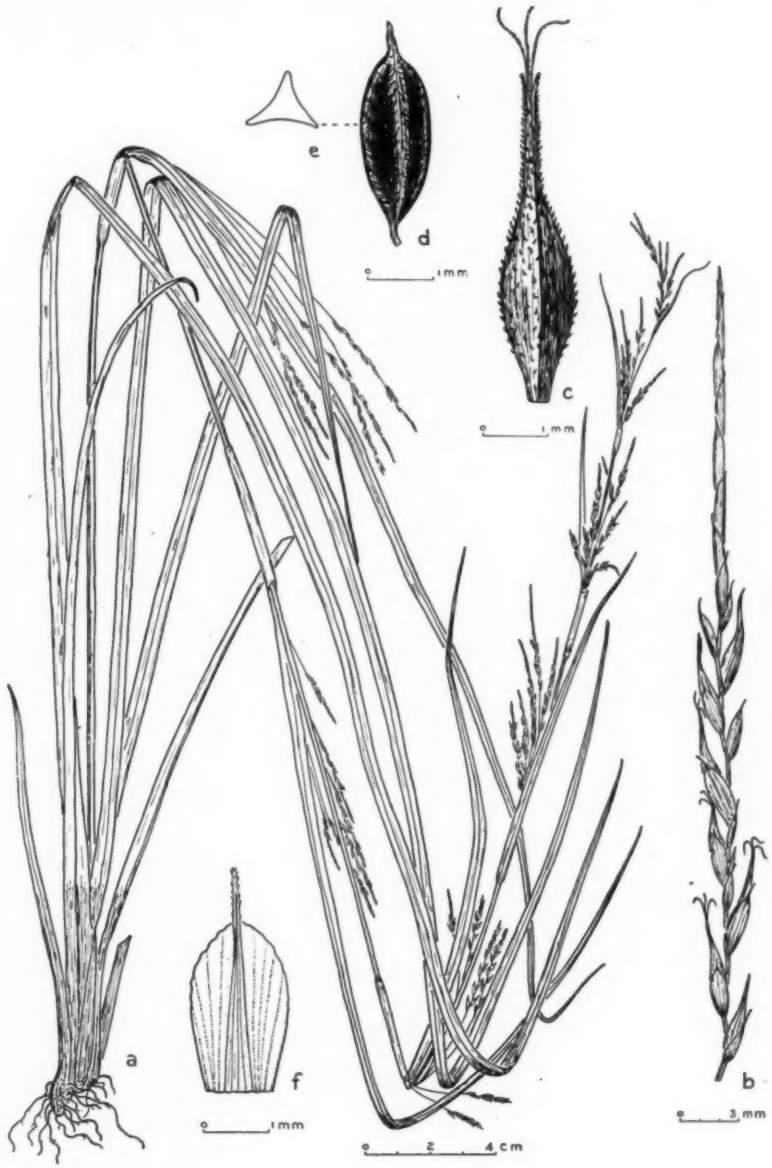

Fig. 1. *a*, habit of type specimen, *St. John 18,330* (× ½); *b*, spike showing pistillate flowers below, and staminate scales above (× 3); *c*, perigynium and stigmas (× 10); *d*, lateral view of achene (× 10); *e*, transverse median section of achene (× 10); *f*, pistillate scale (× 10).

base, contracted to the indurated cylindric persistent 0.2 mm. style base which is straight or slightly twisted.

FIJI ISLANDS: Viti Levu, Taunaisali, Wainisavulevu-Nubulolo divide, the central plateau between the Wainimala and Singatoka Rivers, clumps in swampy rain forest, 3,800 feet altitude, August 18, 1937, *H. St. John 18,330* (**type** in Bishop Mus.).

There have been only three species of *Carex* known in the Fijian flora and none of them appears to be closely related to this new species.

The new *C. vitiensis* is a member of the subgenus *Eucarex* and apparently is to be placed within the ample limits of section *Elatae*. No very close relative is known, but it appears to be somewhat remotely related to *C. longebrachiata* Boeck. (*C. longifolia* R. Br., not of Thuill. or Host) of eastern Australia. *C. longebrachiata* Boeck. has the leaves exceeding the culms, coriaceous; the spikes androgynous or gynecandrous or rarely unisexual, the upper 1–2 strictly staminate, the others pistillate, spikes rather densely flowered, narrowly cylindric, often pendulous; the perigynium 6 mm. long, long attenuate to the base, broadest near the middle, the beak about 1/4 of the total length; and the achene obovate above the stipitate base, densely punctate, the indurated base of the style contorted. In contrast, the new *C. vitiensis* has the leaves about 4/5 the length of the culms, chartaceous; the spikes androgynous, only the terminal ones largely staminate; spikes loosely flowered, very slender cylindric, erect or the tips slightly diverging; the perigynium 4.8–5.2 mm. long, short attenuate to the base, broadest 1/3 of the way from the base, the beak about 1/3 of the total length; and the achene narrowly elliptic above the stipitate base, smooth and shining, the indurated base of the style straight or slightly twisted.

The specific name is derived from the name of the island, Viti Levu, where the plant grows.

NOTES

Facilities for Research in the Natural Sciences in the Hawaiian Islands

MORE THAN TWENTY AGENCIES or institutions, both governmental and private, possess facilities for research in the natural sciences in the Hawaiian Islands. The following inventory of these facilities has been prepared from responses by the heads of the various organizations. It is believed that this alphabetic listing will be valuable not only to scientists visiting Hawaii or corresponding with agencies in this region, but also to residents of these islands who have not previously been able to examine a complete list of local research facilities and opportunities. Similar inventories of research facilities in the natural sciences in other areas of the Pacific region are planned for future issues of PACIFIC SCIENCE.

BERNICE P. BISHOP MUSEUM

ADDRESS: Bernice P. Bishop Museum, Honolulu 35, Hawaii. Director: Dr. Peter H. Buck.

PURPOSE: Collection, preservation, and study of Hawaiian and kindred Pacific material in ethnology and the natural sciences; publication of results of study. (Only the natural sciences will be covered in the present listing.) The Museum is affiliated with Yale University, and the Director is a professor on the Yale faculty.

SUBDIVISIONS: Departments of Botany, Malacology (terrestrial and marine), Entomology, and Marine Zoology; also large collections in ichthyology, ornithology, and geology.

PERSONS ENGAGED IN RESEARCH: (botany) Dr. Harold St. John, Marie Neal, Edward Y. Hosaka, Dr. F. B. H. Brown (unofficially attached); (malacology) Dr. C. Montague Cooke, Jr., Yoshio Kondo, Wray Harris (marine); (entomology) E. C. Zimmerman; (marine zoology) Dr. C. H. Edmondson; (ornithology) Paul H. Baldwin (absent on leave). The Museum also has on its staff four honorary consultants and 11 honorary associates in the natural sciences.

OPPORTUNITIES FOR FIELD RESEARCH: The Museum budget includes appropriations for field expenses. Trips among the Hawaiian Islands and special expeditions to other parts of the Pacific area are carried out from time to time.

LIBRARY: The Library has an estimated 25,015 books and 11,580 pamphlets. These are chiefly on Pacific ethnology and natural history, with emphasis on Polynesia. No important report of an early voyage into the Pacific is lacking. There are complete files of many scientific publications from American institutions, as well as excellent files from institutions in all other parts of the world having interest in the Pacific. New books on pertinent subjects are acquired as they appear, and the Library attempts to fill the needs of the members of the staff.

COLLECTIONS: The Museum is designated by territorial law as the depository for natural history collections of the University of Hawaii and other territorial departments, bureaus, and boards. In addition to a large area devoted to ethnology (the Museum has the largest collection of Hawaiian artifacts in the world), the following collections are available in the natural sciences: (1) *Botany:* Herbarium contains what is probably the largest collection of Polynesian plants; the total number for the Pacific area is 150,000 specimens. (2) *Malacology:* Synoptic collection of land and marine shells on exhibition; land shell collection is well over 2,000,000 specimens and marine shell collection over 50,000 (3) *Entomology:* Collection numbers over 400,000 specimens. (4) *Ornithology:* Contains many specimens of extinct Hawaiian birds. (5) *Ichthyology:* Large collection of fish; also fine set of colored casts on exhibition.

PUBLICATIONS: Four series are published by the Museum. (1) *Memoirs* (quarto); 12 volumes containing 39 papers published to date. (2) *Bulletins* (royal octavo, over 50 printed pages); 188 published to date. (3) *Occasional Papers* (octavo, under 50 printed pages); 18 volumes, totaling 274 papers, published to date. (4) *Special Publications;* 37 published to date. List of publications may be obtained from the Director.

RESEARCH FELLOWSHIPS: Two Yale University–Bishop Museum Fellowships of $2,000 were offered annually by Yale University and Bishop Museum for research work on ethnology and the natural sciences of the Pacific area. They were discontinued during the war but will be resumed in the near future.

RESEARCH OPPORTUNITIES: Other opportunities are offered by the Museum from time to time as the need arises and the funds permit. Materials in botany, entomology, and marine zoology are sent out to specialists in America and Europe for identification, and the reports are published by the Museum.

RESEARCH POLICY: The Museum offers research facilities to visiting scientists to study its collections. Office space is provided. The Museum recently provided desk accommodation for 10 scientists and 20 typists who worked on the reports of the United States Commercial Company's economic survey of Micronesia. During the proposed Pacific Science Survey, the Museum is prepared to give office accommodation to research workers in ethnology and the natural sciences, as well as free access to its collections.

California Packing Corporation

ADDRESS: California Packing Corporation, P. O. Box 149, Honolulu 10, Hawaii.

PURPOSE: Since the corporation is primarily a production organization, research facilities are confined to those necessary to growing and canning fruits and vegetables. Research in agriculture is carried on by Maxwell O. Johnson. The corporation is also served by its main office in San Francisco and by the Pineapple Research Institute.

FACILITIES: Laboratory facilities in Honolulu are limited to those required for simple analysis and control of canning operations.

Hawaii National Park

ADDRESS: U. S. Department of the Interior, National Park Service, Hawaii National Park, Hawaii. Superintendent: Frank R. Oberhansley.

PURPOSE: The Park Service is primarily an operating organization; research by the field staff is encouraged when time permits.

SPECIAL SUBDIVISIONS: Naturalist Department; Hawaiian Volcano Observatory (for description of this Observatory see listing below under "Hawaiian Volcano Observatory").

PERSONS ENGAGED IN RESEARCH: G. O. Fagerlund, botany; Clifton J. Davis, entomology.

FACILITIES: Offices, laboratories, and photographic darkroom.

OPPORTUNITIES FOR FIELD RESEARCH: Year-round access to area of contrasted physiographic, climatic, and ecological conditions.

LIBRARY: A few hundred volumes on biology.

COLLECTIONS: Fairly complete classified collection of plants, birds, and insects of the Park area.

PUBLICATION SERIES: Mimeographed *Natural History Bulletins* interpreting natural conditions, published occasionally.

RESEARCH POLICY: The Service co-operates in every way within its means to encourage institutions and individuals to conduct research in its areas.

Hawaiian Pineapple Company

ADDRESS: (Dole) Hawaiian Pineapple Company, Ltd., Honolulu 1, Hawaii.

PURPOSE: Research pertaining to the growing and processing of pineapples and other subtropical crops.

STAFF: Technically trained persons engaged in research number 25. Staff includes Dr. F. P. Mehrlich, Assistant Vice President in Charge of Research; Dr. George E. Felton, Chemist; Dr. R. O. Belkengren, Food Biochemist; Dr. Dillon S. Brown, Horticulturist; Dr. Melvin Levine, Bacteriologist; Kenneth Kopf, Geneticist.

FACILITIES: Laboratories in Honolulu for chemical research, frozen food research, food technology, bacteriology, and plant physiology. Laboratory at Wahiawa for horticultural, genetic, agronomic, and plant physiology research. A similar laboratory on Lanai. Pilot plants and special processing lines of commercial equipment are available in the Honolulu factory.

OPPORTUNITIES FOR FIELD RESEARCH: Comprehensive field research is carried on relative to agronomy, horticulture, genetics, and plant physiology.

LIBRARY: The library contains about 500 volumes.

Hawaiian Sugar Planters' Association

ADDRESS: Experiment Station, Hawaiian Sugar Planters' Association, 1527 Keeaumoku Street, Honolulu 4, Hawaii. Director: Dr. Harold L. Lyon.

PURPOSE: To investigate and solve the field and factory problems of the Hawaiian sugar industry.

SUBDIVISIONS: Departments of Agriculture, Botany and Forestry, Chemistry, Climatology, Entomology, Genetics, Geology, Pathology, Physiology and Biochemistry, and Sugar Technology. Each department is headed by an outstanding scientist.

PERSONS ENGAGED IN RESEARCH: About 6[illegible] research workers.

FACILITIES: Each department has at its disposal all the facilities and equipment necessary for research in its special field.

LIBRARY: The library contains 25,860 volumes and thousands of separates, bulletins, and pamphlets, all properly classified.

COLLECTIONS: A very extensive collection of insects of the Pacific ocean area; museums of sugar canes and cane diseases.

PUBLICATIONS: *The Hawaiian Planters' Record*, a magazine now in its fiftieth volume. Members of the organization are encouraged to publish results of research in various scientific journals.

RESEARCH FELLOWSHIPS: None offered at present.

RESEARCH POLICY: The Station always welcomes visiting scientists and strives to assist them in every way possible. During the year 1946, the Station gave assistance in the field, laboratory and library to sugar cane experts from Australia, China, Cuba, Mauritius, and Tanganyika.

Hawaiian Tuna Packers

ADDRESS: Hawaiian Tuna Packers, Ltd., P. O. Box 238, Honolulu, Hawaii.

FACILITIES: At the present time the company does not have facilities for scientific research, as this organization, primarily engaged in processing, is only slowly getting its activities back to a prewar basis of operation, and hopes to reach normal production by the latter part of 1947.

Hawaiian Volcano Observatory

(Branch of Hawaii National Park collaborating with Hawaiian Volcano Research Association and the University of Hawaii)

ADDRESS: Hawaiian Volcano Observatory, Hawaii National Park, Hawaii. Volcanologist in charge: R. H. Finch.

PURPOSE: To maintain measurements and observations on the active volcanoes Kilauea and Mauna Loa and to conduct research on the physics and chemistry of volcanoes by seismic, magnetic, or other available methods and to devise and test new methods.

PERSONS ENGAGED IN RESEARCH: R. H. Finch, Volcanologist; Dr. H. A. Powers, Seismologist; B. J. Loucks, Instrument Maker; occasional visiting specialists.

FACILITIES: (1) Hawaii National Park Naturalist-Observatory Building (laboratories, seismograph vaults, instrument shop, darkroom). (2) University of Hawaii Kilauea Laboratory (separate laboratory and office buildings, miscellaneous instruments, collections, records, etc.). (3) Seismograph stations at other points on the island of Hawaii.

OPPORTUNITIES FOR FIELD RESEARCH: Proximity to Kilauea Crater and accessibility of Mauna Loa. Opportunity for studies in petrology, areal geology, volcanic processes, and varied geophysical measurements.

LIBRARY: Specialized collection of books, journals, and reprints in volcanology and related subjects. (See also below, "Hawaiian Volcano Research Association, Library.")

PUBLICATION SERIES: *Hawaiian Volcano Observatory Bulletin,* 1912–1929, and *Special Reports* (both in collaboration with Hawaiian Volcano Research Association); *Volcano Letter,* 1925 to date (in collaboration with Hawaiian Volcano Research Association and University of Hawaii). A number of publications by staff members have appeared in various scientific journals.

RESEARCH FELLOWSHIPS: See "Hawaiian Volcano Research Association, Research Fellowships."

RESEARCH POLICY: Cordial collaboration; desk space and laboratory facilities afforded to visiting scientists.

Hawaiian Volcano Research Association

ADDRESS: Hawaiian Volcano Research Association. President: L. P. Thurston; Secretary: L. W. de Vis-Norton, 320 James Campbell Building, Honolulu, Hawaii; Scientific Director: Dr. T. A. Jaggar, University of Hawaii, Honolulu 10, Hawaii.

PURPOSE: To sponsor research in physical processes of Hawaiian volcanoes. The Association co-operates in research with the Hawaiian Volcano Observatory.

PERSONS ENGAGED IN RESEARCH: (At University of Hawaii) Dr. T. A. Jaggar, Research Associate in Volcanology, and R. A. Okuda, Junior Researcher; (at Hawaii National Park) staff of Hawaiian Volcano Observatory.

FACILITIES: (1) Kilauea Laboratory of the University of Hawaii (instrument shop, collections, files, instruments, maps, records, etc.); (2) Hawaiian Volcano Observatory at Hawaii National Park (see "Hawaiian Volcano Observatory"); (3) Volcanology Laboratory, Room 2, Home Economics Building, University campus.

LIBRARY: (At Hawaiian Volcano Observatory, Hawaii National Park) Many volumes, record books, reprints, journals, maps, instrument designs, and seismograms.

EXHIBITS: (At Hawaii National Park) Volcanic specimens, photographs, models, and exhibition seismograph.

PUBLICATION SERIES: See "Hawaiian Volcano Observatory."

RESEARCH FELLOWSHIPS: The Directors will receive applications at any time from research investigators holding doctorate degrees who desire to pursue specialized Hawaii studies in seismology, volcanology, and volcanological oceanography. Persons of advanced grade holding fellowships from mainland colleges may be assisted in travel expense and provided with apparatus or use of facilities. Address inquiries to: Dr. T. A. Jaggar, Scientific Director, University of Hawaii, Honolulu 10, Hawaii.

RESEARCH POLICY: To encourage highly skilled, specialized research on Hawaiian volcanology, seismology, and related phenomena. Desk space and laboratory facilities are offered to visiting scientists.

Honolulu Board of Water Supply

ADDRESS: Honolulu Board of Water Supply, P. O. Box 3410, Honolulu 1, Hawaii.

PURPOSE: To maintain, expand, and improve the Honolulu water supply.

SUBDIVISIONS (engaged in other than service activities): Division of Geology (Dr. C. K. Wentworth and two others); Division of Chemistry (L. T. Bryson and one other); Division of Bacteriology (J. M. Downer and four others).

FACILITIES: Separate laboratories for the three divisions, with supplementary darkroom, microscope room, and storage and office space.

Equipment for general studies in areal geology and petrography, chemical analyses of water and other materials, special studies of corrosion and other impairment, bacteriology of water, and the like.

OPPORTUNITIES FOR FIELD RESEARCH: (1) Work in geology includes field mapping of structures and ground-water features, laboratory and field experiments in hydrology, and collection of data and mathematical studies in meteorology and hydrology (the latter in collaboration with the Division of Water Resources of the Board of Water Supply). (2) Work in chemistry includes analysis of daily samples, annual complete analyses of water from various sources, and required special analyses, as well as tests of fuel oil, metals, and construction materials; studies of corrosion or other failure as needed. (3) Work in bacteriology includes daily sampling at sources and at points in the distribution system, with special test programs to maintain required and recognized standards for potable water.

LIBRARY: About 100 feet of shelves containing technical books and journals on engineering, water supply, and related technical subjects.

COLLECTIONS AND EXHIBITS: Working collections of rocks and drill cores; photograph files; occasional charts and technical exhibits.

PUBLICATIONS: Biennial reports containing records of quantities and costs, analyses, and other pertinent data, with occasional technical appendixes. A few supplementary reports have also been published on geology, ground water, water law, and similar subjects.

RESEARCH POLICY: Cordial informal relations with visiting engineers and scientists.

Libby, McNeill and Libby

ADDRESS: Libby, McNeill and Libby, Pineapple Division, P. O. Box 1140, Honolulu 7, Hawaii. Manager of Research: Dr. O. C. Magistad.

PURPOSE: This company conducts research both on pineapple production and on processing.

STAFF: About 10 men devote full time to research problems under supervisory staff of university graduates in chemistry or agriculture.

FACILITIES: In addition to main laboratory in the Libby Cannery, field laboratories have been provided on the islands of Oahu, Molokai, and Maui.

Pacific Chemical and Fertilizer Company

ADDRESS: Research Division, Pacific Chemical and Fertilizer Company, P. O. Box 48, Honolulu 10, Hawaii.

PURPOSE: (1) To conduct investigations in the chemical and agricultural fields related to the company's business. (2) To co-operate with local research organizations such as the Experiment Station of the Hawaiian Sugar Planters' Association, the Pineapple Research Institute, and the University of Hawaii Agricultural Experiment Station on research problems of mutual interest. (3) To conduct or direct research for clients on a contractual basis. (4) To act as consultants in chemistry and agriculture.

STAFF: Four chemists, one chemical engineer, one agricultural technologist, and five additional employees. The division is under the direction of Dr. John H. Payne.

FACILITIES: Laboratory area of 5,000 square feet.

LIBRARY: Technical library of some 1,500 volumes.

PUBLICATIONS: Papers are published (most commonly in chemical periodicals) by staff members from time to time.

RESEARCH OPPORTUNITIES: The company offers no research fellowship at present. Facilities are available to visiting scientists.

Pineapple Research Institute of Hawaii

ADDRESS: Pineapple Research Institute of Hawaii, P. O. Box 3166, Honolulu 2, Hawaii. President and Director: Dr. Eugene C. Auchter.

PURPOSE: The Institute, which had its beginnings about 1912, is supported by the pineapple industry of Hawaii. It is located on land adjoining the University of Hawaii and co-operation with the University is arranged in the study of problems of mutual interest. The purpose of the Institute is to conduct research on all problems encountered in the production of pineapple plants and fruit.

SUBDIVISIONS: Departments of Entomology, Plant Pathology, Plant Physiology, Genetics, Chemistry, Agricultural Engineering, Meteorology, and Publications.

STAFF: About 40 scientists are engaged in research. Additional employees include business organization, secretarial staffs, and farm labor. Department heads include Dr. E. G. McKibben, agricultural engineering; Dr. M. B. Linford, pathology; Dr. J. L. Collins, genetics; Dr. Walter Carter, entomology; Dr. G. T. Nightingale, plant physiology; Dr. Harold E. Clark, chemistry; L. B. Leopold, meteorology; and Joyce Roberts, publications. Many of the associates hold doctorate degrees.

FACILITIES: Well-equipped laboratories are available in all departments.

OPPORTUNITIES FOR FIELD RESEARCH: Greenhouses, shade houses, and an experiment station of 100 acres (located at Wahiawa, Oahu) are available. Research may also be carried on in the pineapple fields of member companies.

LIBRARY: The library contains 4,352 bound and unbound volumes and several hundred special pamphlets; 101 research journals and technical publications are received regularly.

EXHIBITS: Permanent exhibits in several branches of research have been set up. An excellent living collection of the various pineapple spe

cies, hybrids, and clones is established on the grounds of the experiment station at Wahiawa.

PUBLICATIONS: *Pineapple News*, 1927–1936; *Pineapple Quarterly*, 1931–1936. Recent policy has been to issue reports of research to the pineapple industry, and to publish papers giving the results of technical investigations in various American and foreign scientific journals.

RESEARCH FELLOWSHIPS: Through an arrangement with the University of Hawaii it is possible for graduate students to prepare their theses under the direction of members of the research staff and to work in the laboratories or at the experiment station. Occasionally research fellowships or research assistantships are offered.

RESEARCH OPPORTUNITIES: Outstanding scientists from the Mainland and elsewhere are often invited to come to the Institute to work on problems of common interest. To such scientists all the facilities of the Institute are made available.

RESEARCH POLICY: The Institute arranges cooperative studies with various scientific agencies both in the Hawaiian Islands and on the Mainland on problems of mutual interest.

Territorial Board of Agriculture and Forestry

ADDRESS: Territory of Hawaii, Board of Commissioners of Agriculture and Forestry, King and Keeaumoku Streets, P. O. Box 3319, Honolulu 1, Hawaii. President: Colin G. Lennox.

PURPOSE: The Board is primarily concerned with law enforcement, but does carry on some research.

SUBDIVISIONS: Division of Fish and Game, which is conducting biological research in fisheries and wild life; Division of Animal Industry, which carries on bacteriological and pathological research on animal diseases; Division of Entomology, which carries on biological research in entomology primarily as it concerns the introduction of insect parasites. Foresters carry on field research from time to time.

PERSONS ENGAGED IN RESEARCH: About nine.

FACILITIES: Laboratories well equipped for all necessary investigations. Laboratory facilities for fisheries and wild life research are available at present through the Department of Zoology, University of Hawaii.

LIBRARY: The Division of Entomology Library consists of about 1,000 volumes, including the principal sets of entomological publications.

COLLECTIONS: Division of Entomology has special collections which include fruit flies of the world, parasitic insects, and general collections made in Africa, Asia, Australia, Mexico, Panama, and Brazil. A permanent exhibit of economically important insects is presented in display cases.

PUBLICATIONS: *Biennial Report; Division of Forestry, Botanical Bulletins* 1–6 (1911–1919); *Hawaiian Forester and Agriculturist*, 1904–1933. Staff members have prepared special reports, bulletins, and articles.

RESEARCH POLICY: No standing offer of research facilities is made, but these have been used on several occasions by visiting scientists with the Board's permission. Inquiries should be addressed to the president of the Board.

Territorial Board of Health

ADDRESS: Territory of Hawaii, Board of Health, Kapuaiwa Building, Honolulu, Hawaii. President: Dr. C. L. Wilbar, Jr.

PURPOSE: General charge, supervision, and care of the health and lives of the people of the Territory.

SUBDIVISIONS: Preventive Medicine; Local Health Services; Medical Services; Central Administration; and Sanitation (including industrial hygiene, food and drugs, rodent and mosquito control, housing). An active research program is carried on by Dr. David S. Bonnet, Medical Entomologist, for the control and prevention of diseases carried by rodents and mosquitoes.

FACILITIES: Adequate laboratories are available in the health department offices on the various islands.

OPPORTUNITIES FOR FIELD RESEARCH: Professional and administrative personnel are busy with ordinary routine duties, but existing programs offer material for much research.

PUBLICATIONS: *Annual Report.*

RESEARCH FELLOWSHIPS: From time to time fellowships are offered to members of the Board's medical, nursing, sanitation, laboratory, and other staffs.

U. S. Bureau of Animal Industry

ADDRESS: U. S. Department of Agriculture, Bureau of Animal Industry, 219 Federal Office Building, Honolulu 2, Hawaii. Inspector in Charge: Dr. A. H. Julien.

RESEARCH POLICY: This bureau is primarily a routine inspection agency, and no research program is carried on at present.

U. S. Bureau of Entomology and Plant Quarantine

ADDRESS: U. S. Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine, Division of Foreign Plant Quarantine, P. O. Box 340, Honolulu 9, Hawaii.

RESEARCH POLICY: This division is primarily an inspection agency, and no research program is carried on at present. (See listing on Fruitfly Investigations division below.)

U. S. Bureau of Entomology and Plant Quarantine (Fruitfly Investigations)

ADDRESS: U. S. Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine, Fruitfly Investigations, University of Hawaii Campus, P. O. Box 340, Honolulu 9, Hawaii. Entomologist in Charge: J. W. Balock.

PURPOSE: Research on the biology, ecology, and chemical control of fruit flies; development of methods of fruit treatment to eliminate risk that living insects of economic importance will be transported through channels of commerce.

STAFF: Normally, three professional workers, one sub-professional worker, and one administrative clerk.

FACILITIES: Well-equipped laboratory for entomological research (refrigeration facilities, vapor-heat room and equipment, constant temperature cabinets, micro-balance, etc.).

OPPORTUNITIES FOR FIELD RESEARCH: Field research conducted in co-operation with individual farmers or on Bureau's own research plots.

LIBRARY: Limited library on general entomology.

PUBLICATIONS: Research results appear in scientific journals and U. S. Department of Agriculture publications.

RESEARCH POLICY: Facilities and laboratory space are willingly made available to visiting scientists interested in these problems. Such facilities have also been made available to local scientists when practicable.

U. S. Coast and Geodetic Survey

ADDRESS: U. S. Department of Commerce, U. S. Coast and Geodetic Survey, Pacific District Headquarters, 244 Federal Office Building, Honolulu, Hawaii. Supervisor, Pacific District: Lt. Comdr. L. C. Wilder.

PURPOSE: The principal functions of the Coast and Geodetic Survey are the surveying of all coastal waters under the jurisdiction of the United States and the production of the nautical charts and coast pilot publications required for the navigation of those waters; the compilation of aeronautical charts for air navigation; and the accomplishment, throughout our country and its possessions, of geodetic control surveys which provide essential basic data for nautical charting and topographic mapping (see U. S. Coast and Geodetic Survey *Special Publication* 216, "The United States Coast and Geodetic Survey," Washington, 1938). Research is carried on principally in the office in Washington, D.C., from field data assembled there; work is principally in seismology, magnetism, tides, currents, and sea water salinities and temperature, and in the development of necessary instruments and equipment for carrying on field work. The principal work in the area directed from Pacific Headquarters is to obtain and make available nautical information, charts, and tide and current tables to the seafaring profession and allied interests.

FACILITIES: At Barbers Point, Oahu, is located the Coast and Geodetic Magnetic and Seismological Observatory, in charge of R. F. White, Geophysicist. It is likely that this observatory will be expanded to handle the correlating of various earthquake reports and possibly of those on seismic sea waves. The Pacific District will soon set up, in co-operation with other agencies, a comprehensive series of tide gages which will also record water salinities and temperatures.

LIBRARY: Limited file of publications upon tides, currents, seismology, magnetism, chart and map making, surveying, and astronomy.

U. S. Geological Survey, Division of Surface Waters

ADDRESS: U. S. Department of the Interior, Geological Survey, Water Resources Branch, Division of Surface Waters, 225 Federal Office Building, Honolulu 2, Hawaii. District Engineer: Max H. Carson. (The Geological Survey is associated with the Territorial Division of Hydrography, of which Mr. Carson is Chief Hydrographer.)

PURPOSE: Collection of reliable records of flow of the principal streams and ditches in the Territory and their interpretation. The organization also collects data on the artesian wells in the Territory and administers the laws relating to the conservation of artesian waters. (See also Ground Water Division, below.)

PERSONS ENGAGED IN RESEARCH: The Geological Survey co-operates with the Division of Hydrography of the Territory, the two organizations functioning as a unit. The staff includes several hydraulic engineers, two engineering aides, and one engineering draftsman in Federal pay; and one hydraulic engineer, two engineering aides, and two clerical employees in Territorial pay.

FACILITIES: A small hydraulics laboratory is situated just below Nuuanu Reservoir No. 3 in Nuuanu Valley. Here, previous to the war, several models of streams were built and tested. At present no laboratory work is being done, but plans call for one engineer to spend full time in laboratory research.

LIBRARY: Consists of U. S. Geological Survey *Water-Supply Papers* 1–1014, *Professional Papers* 42–207, *Bulletins* 600–930, *Annual Reports* 17–25, *Miscellaneous Mineral Reports*, various monographs, and more than 500 state and miscellaneous reports and textbooks.

PUBLICATION SERIES: Publications of the Survey on Hawaii are a part of the series of U. S. Geological Survey *Water-Supply Papers*. Num

bers of the series pertaining to Hawaii are 77, 318, 336, 373, 430, 445, 465, 485, 515, 516, 535, 555, 575, 595, 615, 635, 655, 675, 695, 710, 725, 740, 755, 770, 795, 815, 835, 865, 885, 905, 935, 965, 985.

RESEARCH POLICY: No special facilities are offered to visiting scientists.

U. S. Geological Survey, Ground Water Division

ADDRESS: U. S. Department of the Interior, Geological Survey, Ground Water Division, 333 Federal Office Building, Honolulu 2, Hawaii. District Geologist: Dr. Gordon A. Macdonald. (See also Surface Water Division, above.)

PURPOSE: Investigation of the geology and groundwater resources of the Hawaiian Islands.

PERSONS ENGAGED IN RESEARCH: Dr. Gordon A. Macdonald, District Geologist; Dan A. Davis, Associate Geologist.

FACILITIES: Laboratory—none. Petrographic microscope.

OPPORTUNITIES FOR FIELD RESEARCH: Excellent.

LIBRARY: About 500 volumes, including U. S. Geological Survey *Professional Papers, Bulletins, Water-Supply Papers.*

COLLECTIONS: Petrologic collections from the Hawaiian Islands.

PUBLICATION SERIES: *Bulletins* of the Hawaii Division of Hydrography.

RESEARCH POLICY: All possible co-operation is offered to provide facilities for visiting scientists.

U. S. Public Health Service

ADDRESS: U. S. Public Health Service, 208 Federal Office Building, Honolulu, Hawaii.

RESEARCH POLICY: No local research program is carried on at present.

U. S. Weather Bureau Office

ADDRESS: U. S. Department of Commerce, U. S. Weather Bureau Office, Federal Office Building, Honolulu 1, Hawaii.

PURPOSE: Weather forecasting for aviation and shipping in the Pacific, as well as for local interests. Collection, summarization, and publication of Hawaii weather records.

SUBDIVISIONS: Forecast Office (John Rodgers Airport), Acting Official in Charge: Charles M. Woffinden; Climatology Office (Federal Office Building), Acting Official in Charge: W. F. Feldwisch.

FACILITIES: Original records available from approximately 300 points in the Hawaiian Islands (chiefly rainfall records). Analyzed weather maps of Northern Hemisphere on file.

LIBRARY: Approximately 100 volumes bearing on meteorology, forecasting, and climatology. Several hundred volumes and various pamphlets of published weather data, mostly from the United States, but some from various other parts of the world.

PUBLICATIONS: Monthly and annual *Meteorological Summary* for Honolulu; monthly and annual *Climatological Data* for the Hawaiian Islands.

University of Hawaii

ADDRESS: University of Hawaii, P. O. Box 18, Honolulu 10, Hawaii. President: Gregg M. Sinclair.

PURPOSE: The University, a land-grant institution of higher learning founded in 1907, offers many opportunities for research in the physical and biological sciences, both in the research programs of faculty and students and in research in co-operation with many of the governmental and other agencies in the Hawaiian Islands, such as the Bernice P. Bishop Museum, the Pineapple Research Institute, the Hawaiian Sugar Planters' Association, and the U. S. Bureau of Entomology and Plant Quarantine. (The work of the University of Hawaii Agricultural Experiment Station is separately reported below.)

SUBDIVISIONS: The University departments which carry on research in the natural sciences, with the names of departmental chairmen, include: Agriculture (Harold A. Wadsworth), Bacteriology (Dr. Floyd W. Hartmann), Botany (Dr. Harold St. John), Chemistry (Dr. Leonora N. Bilger), Geology (Dr. Harold S. Palmer), Physics (Dr. Willard H. Eller), and Zoology and Entomology (Dr. Robert W. Hiatt). Certain members of the University faculty are assigned, as part of their duties, to carry on research at the Bishop Museum.

PERSONS ENGAGED IN RESEARCH: In addition to the department chairmen mentioned above, the University faculty in the natural and physical sciences includes: (Agriculture) Louis A. Henke, Dr. William B. Storey; (Bacteriology) Dr. Oswald A. Bushnell; (Botany) Dr. Charles J. Engard, Dr. Donald P. Rogers; (Chemistry) Dr. Earl M. Bilger, Dr. Frederick G. Mann, Dr. Robert C. Brasted, Dr. Robert D. Bright, Dr. Robert A. Spurr; (Physics) Dr. E. H. Bramhall, Iwao Miyake; (Zoology and Entomology) Dr. Frederick G. Holdaway, Dr. Joseph E. Alicata, Dr. Albert H. Banner, Dr. Harvey I. Fisher, Dr. Pauline Heizer, Dr. Gordon B. Mainland, Dr. Leonard D. Tuthill.

FACILITIES: Laboratory facilities are available on the University campus, in Gartley Hall for chemistry and physics, and in Dean Hall for botany, geology, zoology, and entomology. Agricultural and nutrition laboratories are found in Gilmore Hall. Other research laboratories on the campus are those of the U. S. Bureau of Entomology and Plant Quarantine, the Pineapple Research Institute, and the University

Agricultural Experiment Station. A large laboratory will be housed in the Agricultural Engineering Institute now under construction, the gift of the Hawaiian Sugar Planters' Association. Off-campus laboratories include the Marine Biological Laboratory and Aquarium at Waikiki, the Astronomical Observatory at Kaimuki, and the Kilauea Laboratory in Hawaii National Park.

OPPORTUNITIES FOR FIELD RESEARCH: Field research trips are organized periodically, under the supervision of University faculty members. In the past these trips have covered not only the outer islands of the Hawaiian Group but also other islands of the Pacific region. As a part of the program of the University's Pacific Islands Research Committee headed by Dean Paul S. Bachman, in December, 1945, four faculty members made a reconnaissance visit to Micronesia, which was followed in the summer of 1946 by teams of scientists who made field surveys in Micronesia particularly in botany, zoology and bacteriology, and parasitology (see PACIFIC SCIENCE, January, 1946, p. 61–62).

LIBRARY: The University Library contains 163,950 bound volumes and 378,829 unbound parts and pamphlets, including the main publications in natural science. A union list of serials in the Library indicates the locations of all periodicals found in all libraries in the Territory. Standard scientific works are to be found on the Library shelves; well represented are works on the botany of the Pacific area, tropical agriculture, marine biology, and chemistry; there are also many volumes on voyages and scientific expeditions to the Pacific. The Library is an official depository for Federal and Territorial governmental publications. Scientific works printed in the Chinese and Japanese languages are included in the Oriental Collection. Visiting scientists are accorded free use of all Library facilities.

EXHIBITS: Collections or permanent exhibits, by act of the Territorial Legislature, are placed in the Bishop Museum, and a considerable part of the botanical and zoological exhibits in that museum is the work of University scientists. The herbarium there housed contains the most nearly complete collection of Hawaiian plants in existence, including some species now extinct. Certain departments of the University arrange displays on the campus from time to time. Large-scale relief maps of the major islands of the Hawaiian Group are to be found in the main lobby of Gilmore Hall. A botanical tour of the campus is described in a free illustrated booklet, *In Green Manoa Valley.*

PUBLICATION SERIES: *Research Publications* (1927 to date); *Occasional Papers* (1934 to date). In January, 1947, the University began publication of PACIFIC SCIENCE, a quarterly devoted to the biological and physical sciences of the Pacific region. *The Volcano Letter,* since 1938, ha been published by the University for the Ha waiian Volcano Observatory and the Hawaiia Volcano Research Association. *Proceedings o the Hawaiian Academy of Science* has bee issued jointly by the University and the Aca emy since 1940.

RESEARCH FELLOWSHIPS: Fellowships are offere in scientific fields, on a half-time basis, to quali fied graduate students.

RESEARCH POLICY: The University, as a fully ac credited institution of higher learning, is de sirous of promoting scientific research in ever possible way, and members of its faculty an staff are allowed time and funds to carry o such research. Co-operative research of man sorts is carried on by arrangement with various other institutions and agencies. It is the polic of the University to extend its hospitality t visiting scientists who wish to arrange for lab oratory and library facilities.

UNIVERSITY OF HAWAII AGRICULTURAL EXPERIMENT STATION

ADDRESS: University of Hawaii Agricultural Ex periment Station, Box 18, Honolulu 10, Hawaii Director: Dr. John H. Beaumont.

PURPOSE: To conduct research and experiment bearing upon the establishment and maintenance of a permanent and efficient agricultura industry in the Territory.

SUBDIVISIONS: Departments of Agronomy, Horti culture, Animal Husbandry, Poultry Husband ry, Nutrition, Soils and Agricultural Chemistry Plant Physiology, Plant Pathology, Vegetable Crops, Parasitology, Entomology, and Agricul tural Engineering.

PERSONS ENGAGED IN RESEARCH: More than 4 Department heads include Dr. J. E. Alicata Dr. H. F. Clements, Dr. W. A. Frazier, Re Guillou, J. W. Hendrix, L. A. Henke, Dr. F. G Holdaway, Carey D. Miller, J. C. Ripperton Dr. G. D. Sherman, and Dr. W. B. Storey.

FACILITIES: Adequate laboratories in Soils an Agricultural Chemistry, Plant Physiology, Nu trition, Poultry Husbandry, Horticulture, an Vegetable Crops. Field experiment stations ar located on the University campus at Honolul at Poamoho on Oahu, at Haleakala on Mau and at Kona on Hawaii.

LIBRARY: University of Hawaii Library and Sta tion Library.

PUBLICATION SERIES: *Annual Report, Bulleti Circular, Technical Bulletin, Progress Note Technical Papers.*

RESEARCH FELLOWSHIPS: Fellowships are offere occasionally, as need arises.

RESEARCH OPPORTUNITIES: Graduate and under graduate research is carried on in collaboratio with the University of Hawaii.

RESEARCH POLICY: Facilities of the Station ar freely offered to visiting scientists.